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NOTES ON REPTILES AND BATRACHIANS OF PENNSYLVANIA, NEW JERSEY AND DELAWARE

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IN view of the increasing interest in the study of our reptiles and batrachians it seems desirable to place on record any facts that may add to our knowledge of the distribution and relative abundance of the various species. The writer therefore offers the following list which is based upon his personal observations in eastern Pennsylvania and southern New Jersey, and upon specimens contained in the splendid collection of the Academy of Natural Sciences of Philadelphia, which includes the collections of Green, Hallowell, A. E. Brown, and Cope, together with local material collected by Samuel Ashmead, Samuel N. Rhoads, Henry W. Fowler, and the writer.

No species are included unless specimens obtained in one of the three States have been examined, and unless otherwise stated the specimens are in the Academy collection.

It follows that a few species which have been recorded from the district under consideration but of which no specimens were accessible have been omitted, and as the notes are only intended as a contribution toward a complete list, no attempt has been made to quote records or observations at second hand. Further collections will undoubtedly extend the range of many species.

Necturus maculosus Rafinesque.—One specimen obtained in

Darby Creek near Essington, Delaware Co., Pa., by Jas. Gardiner, March 2, 1900, is the only example I have ever seen from this vicinity.[1]

Cryptobranchus alleghaniensis (Daudin). —Mainly west of the Alleghanies. Specimens examined from the Beaver and Allegheny Rivers and also from the Susquehanna near Tucquan, Lancaster Co., where it was occasionally taken by the late Jacob Stauffer, of Lancaster, Pa.

Amblystoma opacum (Gravenhorst).— I have never personally collected this species but have examined specimens from

New Jersey, Atlantic City (W. J. Fox), Beesley's Point (Ashmead), and Medford (J. S. Wills);

Delaware, Newark (T. B. Wilson).

Amblystoma punctatum (Linné).—Occasional but not an abundant species.

Pennsylvania, Philadelphia (J. W. Tatum), Ardmore, Mont. Co. (I. N. De Haven), Clifton, Delaware Co. (B. Wainwright), York Furnace, York Co. (Stone), Chambersburg (Rhoads).

Amblystoma conspersum Cope.—Cope's type specimen from Londongrove, Chester Co., Pa., is the only one I have seen from this district.

Amblystoma bicolor (Hallowell).— I have seen only the type specimen from Beesley's Point, N. J.

Amblystoma tigrinum (Green).— Specimens have been examined from Beesley's Point, N. J. (S. Ashmead, G. H. Horn), and from Crosswicks, N. J. (J. H. Slack). I have never taken it in Pennsylvania.

Amblystoma jeffersonianum (Green).—One specimen in the Academy collection was obtained by Dr. Hallowell "near Philadelphia." I know of no other captures.

Hemidactylium scutatum (Schlegel).— Five specimens were obtained by S. N. Rhoads at Swartzwood Lake, Sussex Co., N. J., in October, 1895, and another from the same County a year later.

Plethodon cinereus (Green).— An abundant species about Philadelphia ranging to the highest parts of the Pennsylvania Alleghanies,—Ganoga Lake, Sullivan Co. (S. Brown)—and to Swartz-

[1] *Cf.* Fowler, *Science*, (n. s.), vol. 11, p. 555, 1900.

wood Lake, northern New Jersey (Rhoads). I have also taken it in Delaware and have examined specimens from as far south as Seaford in that State.

It has always been my experience that this and the following species are nowhere equally abundant; one or the other always predominates.

Plethodon glutinosus (Green).— I have never taken this salamander about Philadelphia or in southern New Jersey, and it seems to be a characteristic species of the mountains or their foothills.

I have examined specimens from the following localities: —

Pennsylvania, Warren Co. (Dr. Kennedy), Venango Co. (Miss Brown), Huntingdon Co. (Dr. Leidy), Juniata Co., York Co., Sullivan Co., Pike Co.

New Jersey, Swartzwood Lake, Sussex Co. (Rhoads).

Gyrinophilus porphyriticus (Green).—This is also a mountain species, and has never so far as I am aware, been taken within the limits of the Carolinian fauna. I have examined the following specimens: —

Pennsylvania, Warren Co. (Dr. Kennedy), Altoona, Blair Co. (Dr. Leidy), Round Island, Clinton Co. (Rhoads), and Tuscarora, Juniata Co. (C. Ingersoll).

Spelerpes bilineatus (Green).—This is a rather common and widely distributed species. I have taken it at various points in Philadelphia, Chester, and Lancaster Co., Pa., as well as in southern New Jersey west of the pine barrens. I have also examined specimens from Atlantic City, N. J., and from Morris Co. (F. Canfield), Swartzwood Lake and White Pond (Rhoads) in the northern part of the State and from Dingman's Ferry, Pike Co., Pa. (Rhoads).

Spelerpes longicauda (Green).—This species is not so plentiful as the preceding and I have never taken it in the southeastern part of Pennsylvania nor in southern New Jersey although there is one in Cope's collection from Atlantic City, N. J.

Farther west in Pennsylvania I have examined specimens from Lancaster Co., Huntingdon Co. (Cope), Cresson, Blair Co., and Round Island, Clinton Co. (Rhoads). In northern New Jersey Rhoads obtained it at White Pond, Warren Co.

Spelerpes ruber (Daudin).—A common species in spring heads. I have taken it in Philadelphia, Chester, and Lancaster Cos., and in Camden Co., N. J. It seems fairly well distributed and has been obtained in the Alleghanies at Round Island, Clinton Co. (Rhoads), and in Blair Co. (Dr. McCook); also at Wilmington, Delaware. I fail to distinguish the variety *montanus* Cope.

Desmognathus ocrophæa Cope.—This seems to be a boreal species and I have only seen specimens from the higher Alleghanies, Harvey's Lake, Luzerne Co. (Stone), Lake Ganoga, Sullivan Co. (Rhoads), and Clinton Co., Pa. (S. Brown).

Desmognathus fusca (Rafinesque).—Probably our most abundant salamander. Found throughout eastern Pennsylvania, northern and southwestern New Jersey, but apparently not in the streams of the pine barrens. In Delaware it occurs in the Brandywine drainage and probably elsewhere.

Desmognathus nigra (Green).—The only Pennsylvania specimen that I have seen is one presented to the Academy by Dr. Holbrook without definite locality.

Diemyctylus viridescens Rafinesque.—An abundant species in the lakes and ponds of the mountainous parts of Pennsylvania and New Jersey; the terrestrial form is common in the hemlock forests.

I have taken it sparingly in York and Chester Cos., but not about Philadelphia nor in southern New Jersey, though Dr. Wilson obtained some near Newark, Delaware.

Bufo lentiginosus americanus (Holbrook).—Everywhere abundant from the mountains to the coast, including the pine barrens.

Acris gryllus crepitans Baird.—I have found this species common along the lower Delaware and Susquehanna valleys. H. W. Fowler has secured it at Cape May, N. J., and S. N. Rhoads obtained it in Sussex, Somerset, and Warren Cos., in the upper part of the State.

Chorophilus triseriatus Wied.—Personally I have not observed this frog but Cope states that it is common in southwestern New Jersey and he also observed it in southern Chester Co., Pa. Rhoads obtained specimens at Pine Grove, Cumberland Co., Pa.

Hyla versicolor Le Conte.—This is the most frequent tree frog during the summer, for the others are seldom seen except when

gathered in the ponds, in springtime. It is quite generally distributed south of the mountains, the most northern specimen that I have examined being from Morristown, N. J. (M. Fisher).

Hyla pickeringii Holbrook.— A common species in shaded pools in early spring. I have examined specimens from the Delaware valley, Chester Co., Pa., and also from Altoona, Blair Co., Pa. (Dr. Leidy), and Pine Grove, Cumberland Co. (Rhoads). Dr. Wilson obtained it in Delaware.

Hyla andersonii Baird.— All the specimens so far secured except the type have come from the pine barren region of New Jersey. Dr. Leidy's specimen from Jackson and one obtained by Mr. H. L. Viereck[1] at Clementon are in the Academy's collection. The others were two secured at Pleasant Mills by Dr. J. P. Moore and one from May's Landing, (J. E. Peters).

Rana pipiens Schreber.— Abundant all along the coast marshes and large rivers. I have examined specimens also from White Pond, N. J., and Waynesburg, Green Co., Pa. (Rhoads), and from several cedar swamps in the New Jersey pine barrens. In the latter region *R. palustris* does not seem to occur.

Rana palustris Le Conte.—Common throughout Pennsylvania and in northern and southwestern New Jersey. It ranges to the top of the Alleghanies as I have seen it in Sullivan and Wyoming Cos., and Rhoads took it at Round Island, Clinton Co., Pa.

Rana sylvatica Le Conte.—Distributed throughout Pennsylvania and New Jersey. I have found it on the highest ranges of the Alleghanies and on the edge of the pine barrens at Medford, N. J., while Rhoads secured a specimen at May's Landing, in the same State.

Rana clamitans Latreille.— Abundant and widely distributed, occurring both in the mountains and in the pine barrens of New Jersey where it is the most abundant frog.

Rana catesbiana Shaw.— Apparently widely distributed but much scarcer than formerly. I have taken it on the lower Delaware and Susquehanna and their tributaries and have seen specimens from Absecon, N. J. (S. Ashmead), and Harvey's Lake, Pa.

[1]Stone, *Proc. Acad. Nat. Sci. Phila.*, 1901. Since this paper was prepared, W. T. Davis has discovered this species and *Rana virgatipes* at Lakehurst in the New Jersey pine barrens (*Amer. Nat.*, vol. 38, p. 893; vol. 39, p. 795).

Rana virgatipes Cope.— All of the specimens of this interesting frog that have been captured, are, so far as I am aware, in the Academy's collection and have been fully reported upon by H. W. Fowler.[1] They are all from the New Jersey pine barrens; the one obtained by the writer was from Speedwell, Burlington Co.

Carphophiops amœnus (Say).—Obtained in Chester and York Cos., Pa., and Pt. Pleasant, Beesley's Point (Ashmead), Trenton (Abbott), and Bridgeton (Walmsley), N. J.

Virginia valeriæ Baird & Giraud.—One specimen is in the Academy collection from Delaware received from C. Drexler.

Storeria occipitomaculata (Storer).— A common snake throughout the mountains south of the Pocono plateau and east of the Alleghanies. I have only seen one example which I captured in the New Jersey pine barrens on the edge of Bear Swamp, east of Medford. This record is interesting as in the same vicinity we find Evotomys, a northern rodent, common in the mountains, but absent in the intervening territory.

Storeria dekayi (Holbrook).— A rather common snake in southeastern Pennsylvania; also obtained at May's Landing, N. J., and doubtless of wider distribution in both States.

Clonophis kirtlandi (Kennicott).—Two examples from the region under consideration are in the Academy collection; one obtained near Trenton, N. J., by Dr. C. C. Abbott, the other in Delaware Co., Pa., by E. Dutton.

Tropidoclonium lineatum Hallowell.— A snake was obtained at Round Island, Clinton Co., Pa., by Seth Nelson collecting for Mr. S. N. Rhoads, which he identified as this species. I examined it at the time and I have no doubt as to the correctness of the identification. Unfortunately the specimen cannot now be found.

Thamnophis sauritus (Linné).—This is a rather common snake throughout the lowlands and probably the mountains also. I have seen specimens from the Pocono plateau, Pa., and Swartzwood Lake, N. J., but not as yet from the main Alleghany range.

Thamnophis sirtalis (Linné).—The Garter Snake is distributed

[1] *Proc. Acad. Nat. Sci. Phila.*, p. 662, 1905.

all over the region under consideration and presents several more or less distinct types of coloration. So far as the material available for examination is concerned it would seem that the dark form with the stripes nearly obliterated, *T. s. ordinatus*, is restricted to the higher Alleghanies as the only specimens are from Sullivan and Wyoming Cos. (Stone) and Port Alleghany, McKean Co. (Fowler). All the specimens that I have seen from south of the mountains are true *sirtalis* with well defined stripes and usually conspicuous spots. Those obtained by Rhoads at Round Island, Clinton Co., Pike Co., Pa., and Sussex Co., N. J., are somewhat intermediate. That these two forms are not absolutely coincident with the Canadian and Carolinian-Alleghanian belts as indicated, is shown by the fact that a fairly typical *sirtalis* was obtained on the high Alleghanies of Sullivan Co., Pa. A nearly uniform green specimen, "*T. s. gramineus*" Cope, was also obtained at the latter locality. This I take to be a mere color form of *ordinatus*.

Thamnophis butleri Cope.— While for some years *Thamnophis brachystomus* Cope has been regarded as a mere abnormal example of *T. sirtalis*, the recent discovery of a number of specimens in Michigan[1] seems to establish its distinctness. The type is from Franklin, Venango Co., Pa. (Miss A. M. Brown) and I am now able to record an additional Pennsylvanian specimen obtained at Port Alleghany, McKean Co., Aug. 19, 1904, by H. W. Fowler. This individual has the plates as follows: upper labials, 6–6; lower labials, 6–7; postoculars, 2–2; gastrosteges, 136; urosteges, 47; length, 377 mm. It presents the principal additional characteristics of the species in a marked degree, *i. e.*, the rapid tapering toward both head and tail, and the very slight constriction at the neck. The lateral stripe is mainly on the third row of scales involving part of the second and at some points part of the fourth row.

After the above was written Alex. G. Ruthven examined the two specimens and pronounces them in his opinion identical with *T. butleri* a conclusion which he had already reached in connection with Dr. Clark's specimens.[2]

[1]H. L. Clark. *Proc. Biol. Soc. Wash.*, vol. 16, pp. 83–88, 1903.

[2]*Biol. Bull.*, vol. 7, no. 5, Nov., 1904.

Regina leberis (Linné).—This does not appear to be a common species and I have never seen it alive. Two specimens marked "Pennsylvania" (J. L. Wortman) are in the Academy collection as well as specimens from Philadelphia (J. E. Ives), Waynesburg, Green Co., Pa. (Rhoads), and Newark, Del. (Dr. T. B. Wilson).

Natrix sipedon (Linné).—Common in suitable localities throughout the region.

Calopeltis obsoletus (Say).—I have only taken this snake in Chester Co., Pa., but have examined several from southern New Jersey, one of which was obtained on the coast at Stone Harbor, by D. McCadden.

Calopeltis obsoletus confinis Baird & Giraud.—One young specimen secured many years ago at Dennisville, Cape May Co., N. J., by Samuel Ashmead is in the Academy collection, and another was secured at Diamond Valley, Huntingdon Co., Pa., September, 1905, by J. A. G. Rehn. While currently referred to this form it seems probable that these are nothing more than young *obsoletus* which at this age may be highly colored, but so far as I know there is no description of the young of this species. The specimens before me are gray with brown spots.

Opheodryas æstivus (Linné).—I have taken this in the southern part of New Jersey only, and have seen no specimens from elsewhere in the district under consideration. It is locally rather plentiful.

Liopeltis vernalis (DeKay).—A common species throughout the Pennsylvania mountains, McKean Co. (Fowler), Sullivan and Wyoming Cos. (Stone), Clinton Co. (Rhoads), Monroe Co. (C. T. Sands). The only New Jersey example that I have seen was taken at Trenton, N. J., by Dr. C. C. Abbott.

Bascanion constrictor (Linné).—Common in the low grounds and at least onto the first ridges of the mountains and though I have not as yet seen a specimen from the main Alleghany range, it no doubt occurs there.

Pituophis melanoleucus (Daudin).—The commonest large snake in the New Jersey pine barrens but I have not seen specimens from farther north in the State nor from Pennsylvania.

Diadophis punctatus (Linné).—Sparingly about Philadelphia but more plentiful nearer to the mountains, over which it ranges. Specimens examined from

Pennsylvania, Bucks Co. (W. A. Shryock), Cumberland Co. (Rhoads), Lancaster Co. (Stone), Monroe Co. (Rhoads), Harvey's Lake, Luzerne Co. (Stone);

New Jersey, Morris Co. (Dr. Fisher).

Lampropeltis getulus (Linné).—A rather common species in southern New Jersey, the most northern record being Pt. Pleasant, Ocean Co. (S. Brown). All the specimens I have examined came from the eastern and western edge of the pine barrens rather than from the heart of the region though this may have been accidental. Rhoads obtained this snake at Seaford, Del., but I have never seen a specimen from Pennsylvania.

Lampropeltis doliatus (Linné).—One typical specimen from Delaware (J. Green) is in the Academy collection and another not quite typical from the same State obtained by Drexler.

Throughout the greater part of eastern Pennsylvania and New Jersey is found *L. d. clericus* and it is everywhere a common snake unless it be in the New Jersey pine barrens from which district I have seen no specimens. Another race, *L. d. triangulus* (Boie), seems to be the form of the higher mountains and is represented in the Academy collection by a specimen from McKean Co., Pa. (Fowler) and one marked near Philadelphia. More material will be necessary in order to ascertain whether these two forms are constant and confined to the districts assigned to them. Certain it is that examples from twenty localities south of the mountains are all *clericus*, the Philadelphia specimen above mentioned being the only exception.

Heterodon platyrhinos Latreille.—Common, ranging from the Alleghanies across to the coast.

Agkistrodon contortrix (Linné).—Becoming scarce in thickly settled districts. I have seen it in York and Fulton Cos., Pa., and have examined specimens from Carbon Co. (Rehn), Lehigh Co. (Rehn), Pottsville (C. T. Hughes), Round Island, Clinton Co. (Rhoads), Pa. I have seen no specimens from New Jersey.

Crotalus horridus (Linné).—I have found this species within the past few years on the foothills of the main Alleghany Mountains near Lovelton, Wyoming Co., and on Tuscarora Mt., Fulton Co., Pa., while Rehn collected several in Huntingdon Co. and Rhoads obtained specimens at Round Island, Clinton Co., and

in Pike Co., Pa., and I have examined additional specimens from Chambersburg (Mrs. P. P. Calvert) and Warren Co., Pa. (Dr. Slack). In the southeastern parts of the State it is exterminated. In southern New Jersey it is very rare and I know of no authentic recent records though there is a specimen in the Academy collection collected many years ago at Pemberton, N. J. (Dr. Coleman).

Eumeces fasciatus (Linné).—I have taken this lizard at York Furnace, York Co., Pa., and J. A. G. Rehn obtained it on the mountains of Huntingdon Co., Pa., where one would rather expect *E. anthracinus*, a species which I know from the State only on the strength of Baird's Carlisle record. In New Jersey it occurs at May's Landing, Jones Mill, and doubtless other spots in the pine barrens. In Delaware I have found it about Choptank Mills. One in the Wagner Institute collection, captured in Fairmount Park, Philadelphia, a few years ago, may have escaped from confinement like the specimens of Phrynosoma and Alligator which are occasionally found within the city limits.

Leiolepisma laterale (Say).—On September 2, 1901, J. A. G. Rehn and I caught one of these little lizards and saw another a mile or so east of Atsion, Burlington Co., N. J., in the heart of the pine barrens. Dr. J. P. Moore had previously taken it at Pleasant Mills some ten miles farther south.

Sceloporus undulatus (Daudin).—Abundant all over the pine barrens of New Jersey, but I have not seen it from north of this region. In Pennsylvania it is rare, though formerly more common. I have only taken it along the lower Susquehanna valley, in York and Lancaster Cos., though Rhoads obtained it at Round Island, Clinton Co., and I have examined a specimen collected in Chester Co. by Cope.

Dermochelys coriacea (Vandelli).—One was washed ashore at Asbury Park, N. J., some years ago, and another from Delaware Bay is in Cope's collection.

Aspidonectes spinifer (Le Suer).—A few of these turtles have of late years found their way into the Delaware valley. One was captured in Cooper's Creek, N. J., in 1902, and another in Warren Co., N. J., now in the Wagner Institute collection, Philadelphia. I have also examined specimens from the Alleghany River in western Pennsylvania.

Chelydra serpentina (Linné).—Widely distributed throughout the region.

Kinosternon pennsylvanicum (Bosc.).—I have so far found this species only in southeastern Pennsylvania and southern New Jersey, ranging as far north as Sea Girt (Rhoads).

Aromochelys odoratus (Latreille).—Apparently more abundant than the preceding and of wider range. I have seen it from the same general region as the above and also from Swartzwood Lake, Sussex Co., N. J. (Rhoads).

Graptemys geographicus (Le Suer).—I found a carapace and plastron of this turtle on the marsh at Bayside, N. J., in the spring of 1903.

Malaclemmys centrata (Latreille).—I have examined specimens from Cape May, N. J. (Dr. Ruschenberger) and the coast of Delaware but have only one recent record, a specimen in the Wagner Institute collection in Philadelphia, captured in Dias Creek, Cape May Co., N. J., a few years ago. It has become rare within the district under consideration.

Pseudemys rubriventris (Le Conte).—I have seen this turtle in ponds and slow streams at several points in southern New Jersey, especially at Medford and Milford and have examined specimens obtained at Woodbury and Rehoboth Beach, Delaware (T. R. Peale). One in the Academy collection is marked "Delaware River, Philadelphia."

Chrysemys picta (Hermann).—This species is abundant in most large streams and ponds throughout the district though I have no data upon its occurrence on the Alleghanies.

Clemmys muhlenbergi (Schweigger).—I have seen probably a dozen specimens of this turtle in W. Bradford township, Chester Co., Pa., and several in Tinicum, Delaware Co. In New Jersey I secured one at Medford, May 30, 1905, and found another near Audubon, Camden Co., in December. The only other specimens that I have examined were labeled "near Philadelphia."

Clemmys insculptus (Le Conte).—Apparently wide ranging but not very common. I have taken it in Chester and Fulton Cos., Pa., and have examined the following additional specimens: Bristol, Pa. (Fowler), Round Island, Clinton Co., Pa. (Rhoads), Delaware Gap, Warren Co., N. J. (Rhoads), and Woodbury, N. J. I have no record for the pine barrens.

Clemmys guttatus (Schneider).—All over southeastern Pennsylvania and southern New Jersey, including the pine barrens but as to its occurrence in the higher mountains I am in doubt.

Terrapene carolina (Linné).—Common throughout southeastern Pennsylvania especially in Chester Co., and also in the southwestern part of the State, Waynesburg, Green Co. (Rhoads). For New Jersey my data are meager but I have no record for the pine barrens. The species seems to be restricted to the Carolinian fauna. Two specimens of *T. triungius* Agassiz are in the Academy collection labeled "*Cistudo clausa*, near Philadelphia, S. G. Worth." The labels must surely have been transposed as this is quite beyond the range of the species.

ANATOMY OF *ACMÆA TESTUDINALIS* MÜLLER

PART I. INTRODUCTORY MATERIAL—EXTERNAL ANATOMY

M. A. WILLCOX

Introduction

Some months ago I published in this journal under the title "Biology of *Acmæa testudinalis* Müller" an excerpt from a monograph of this species upon which I have long been engaged. I have now decided to publish the entire monograph in sections of which the present is the first. It should naturally be introduced by remarks upon the scope of the work but as these were prefixed to the earlier article, I refer the reader to that, adding merely that the investigation is intended not only as a contribution to a knowledge of the New England fauna but also as a first step in such a careful comparative study of the different species of the genus as is there suggested. This being its aim, it occupies itself in the main with anatomy, touching only incidentally upon either histology or embryology. I have, moreover, tried to make a paper which would serve as an introduction to the study of the neglected but fascinating group of Gastropoda. This aim will, I trust, serve as excuse for the admission of some material too elementary to be included in a paper addressed exclusively to specialists.

Zoölogical Position of Acmæa and its Allies

Acmæa belongs to the Scutibranchiata (Aspidobranchia, Diotocardia of Bouvier *et al.*), a suborder which includes all the more primitive Prosobranchiata and which is divisible into two sections: the Rhipidoglossa (Diotocardia of Remy Perrier) and the Docoglossa (Heterocardia). The only characteristics by which members of these two sections may infallibly be distinguished are first, the nature of the radula and second, the presence of dialy-

neury in the nervous system of the Rhipidoglossa and its absence in the Docoglossa. Dialyneury, it will be remembered, is the name applied to that form of nervous system in which the mantle is innervated in part from the pleural and in part from the visceral ganglia and in which these two systems of nerves are connected by anastomosis. It may be added that the ventricle in Rhipidoglossa is usually traversed by the rectum although the Helicinidæ, which have but one auricle, are an exception to this rule.

The Rhipidoglossa fall into two subsections: the Zygobranchia, characterized by the possession of two gills and two auricles, which are usually symmetrically disposed, although one gill may be smaller than the other; and the Azygobranchia with but one gill and ordinarily with two auricles, one of which is more or less rudimentary or even absent altogether. The Docoglossa have a single gill (ctenidium) or none at all, a single auricle with no trace of a second,[1] and a heart whose ventricle is never traversed by the rectum. It is thus evident that the three divisions of Scutibranchiata form in many respects a continuous anatomical series whose members, whatever the view as to their phylogenetic relationship, may often be profitably compared.

The Docoglossa[2] include three families: the Lepetidæ, Acmæidæ, and Patellidæ. The Lepetidæ is a small family whose members inhabit water of considerable depth. Of its fourteen species and varieties only one is recorded as living at low-water mark; the others have been dredged at depths varying from ten fathoms (five fathoms in one instance) to thirteen hundred ninety-five fathoms. While in certain respects, as in the shell and radula, they exhibit relationship to the Rhipidoglossa, in others they are modified in correlation with their environment so that they appear to be, as maintained by Dall, less typical Docoglossa than are the others. The family contains three genera: Lepeta, (including Pilidium), Propilidium, Lepetella.

The two remaining families are much larger and are typically

[1] Spillmann (:05, pp. 569–571) considers that he has found traces of a second auricle.

[2] In the classification of the Docoglossa I follow Pilsbry (Tryon and Pilsbry, '91).

litoral animals. The first one, the Acmæidæ, comprises those limpets which retain the primitive gill (ctenidium) with or without a cordon of branchial leaflets; the second, the Patellidæ, comprises those which lack a ctenidium but have a branchial cordon. The Acmæidæ contains three genera: Pectinodonta, with one species, a deep-sea form found off some of the West Indian islands; Acmæa, with eighty-four species, of almost world-wide distribution; Scurria (including the subgenus Lottia), whose five species are found only on the West American coasts, as far north as San Francisco. The Patellidæ contains also three genera: Patella (including the subgenus Helcion and the sections Patina, Scutellastra, Ancistromesus, all often regarded as genera), with forty-eight species which with one exception (*P. mexicana*) are entirely restricted to the Old World; Nacella, whose seven species are found only in the region about the southern part of South America; Helcioniscus, with forty-eight species in various portions of the Indian and Pacific Oceans but not extending on the American coast farther north than Chili.

History of Investigation

The name *Patella* (*Acmæa*) *testudinalis* first appears in 1776 in Müller's *Prodromus* but more than fifty years went by before any record was made of so obvious a feature in its anatomy as the possession of a ctenidium. It was the observation of this fact which led Eschscholtz to establish in 1830 the new genus Acmæa. As is well known, his early death left uncompleted the *Zoologischer Atlas* which was to have embodied the results accumulated during the years of his circumnavigating voyages. Such material as was in condition to be used by another was completed by his friend Rathke and published in 1833 as a fifth part of the *Atlas*. It contained an anatomical account, covering two folio pages, of the new genus Acmæa followed by brief descriptions, dealing with only the shells, of eleven species collected by Eschscholtz in the neighborhood of Sitka.

This first anatomical study is purely description and is of merely historic interest. The points touched upon are only the more

obvious ones; the account contains some unquestionable errors and some statements which if correct, do not apply to all members of the genus.

A step in advance was marked by Dall's successive papers on the limpets of which the first appeared in 1869. These papers deal mainly with the Acmæidæ and although preëminently systematic, contain occasionally anatomical facts of interest and importance.

The first considerable contributions to the morphology of Acmæa are contained, however, in two papers on the comparative anatomy of certain organs of Prosobranchs which issued from the laboratory of Professor E. Perrier about fifteen years ago. The first of these papers, (Bouvier, '87) dealt with the nervous system; the second, (Bernard, '90) with the pallial organs. Bouvier ('87, pp. 15–22) gives a full and careful description of the nervous system of Patella and in a single paragraph compares therewith the very similar one of *A. testudinalis.* Bernard describes in detail the osphradium and the innervation of the gill in a species of Tectura (Acmæa) and in the same connection figures and describes the arrangement of the principal ganglia in what he calls *T. fontainesi.* It should be noted that this latter species is without doubt, as I have shown elsewhere, (Willcox, 00) incorrectly named and that the identification of the other, so far as concerns the species, is questionable. The so called *Tectura fontainesi,* having circumpallial branchial lamellæ (Bernard, '90, p. 217) is of course not a true Tectura (Acmæa) but may very probably be a Scurria. *T. pileopsis,* Bernard's other species, is stated by him ('90, p. 217) to have come from Chili but that species is recorded by Pilsbry (Tryon and Pilsbry, '91, p. 57) as belonging to the New Zealand, Indo-Pacific, and Australian region.

The first work in which Acmæa was treated monographically was Haller's *Studien über docoglosse and rhipidoglosse Prosobranchier,* which appeared in 1894. This deals with one species of Scurria and three of Acmæa and as it treats all the important organs of the body except the shell, it would at first sight seem to render superfluous further work upon the small family of Acmæidæ. Various statements made by Haller have, however, been the object of vigorous criticism and in other particulars which

have not yet come under public discussion I have found myself unable to adopt his views or to confirm his observations. It is unfortunate that of Haller's four species three are incorrectly named (*cf.* Willcox, :00). One, *Scutellina galathea*, is in all probability an Acmæa but its specific name can only be surmised; for his two other Acmæas he employs the name Lottia, a synonym which was not only discarded by its author some sixty years ago but which has been since 1865 in use for another genus or subgenus, so that the Lottia of Haller is an entirely different animal from the Lottia of Carpenter and modern authors in general.

In 1898, appeared a brief monographic account by myself of *A. fragilis*. This paper dealing as it did entirely with preserved material which was studied almost exclusively by means of sections, left room for such completion and enlargement as is presented in the present work. In 1904, appeared an excellent paper on the anatomy of *Lottia gigantea* by W. R. Fisher to which I shall frequently have occasion to refer. The latest contribution is an article by Spillman in which (:05, pp. 553–564, 568–572) the heart and vessels of Acmæa are described.

Other papers which in the last decade have discussed the Acmæidæ have been occupied mainly with criticism of some of Haller's statements and with the presentation of counter observations. The chief matters in dispute have been the existence of a cœlom as distinct from the pericardial, nephridial, and gonadial cavities, the extent of the nephridium, the presence of a subradular organ. The chief disputants have been Haller, Pelseneer, Thiele, Willcox.

Methods

The first problem which faces any student of the Mollusca relates to narcotization. This is a much less important question among the limpets than in most other groups since the form of the body is such that no great amount of distortion can be effected even by the most powerful contraction. Proper extension of mantle and tentacles are the main results to be attained. For these purposes I have employed various methods — Epsom salts, cocaine, chloretone, stale sea water, fresh water. No one of these

methods was altogether successful. The cocaine — a 2% solution in 50% alcohol added drop by drop — produced extension of gill and cephalic tentacles. In specimens killed after this treatment, the subradular organ was likely to be extruded. Chloretone — crystals gradually added to sea water — produced at first a general extension but a larger dose brought about contraction. This agent is especially useful for narcotizing parts — as gills or tentacles — which it is desired to study while still alive. Extension of mantle tentacles is best obtained by killing in Gilson's fluid, extension of the mantle in general by this method or by allowing the animal to die in stale sea water, or, as recommended by Fisher, in fresh water.

The most satisfactory killing agents I have found to be picro-sulphuric acid, chrom-alcohol (equal parts of 70% alcohol and $\frac{1}{10}$% chromic acid), and corrosive sublimate with 5 to 20% of acetic acid. A weak — 5% — aqueous solution of sublimate preserves the external cilia better than a stronger one; this solution also I have employed with success for material in which it was desired to demonstrate mucus. The various osmic acid solutions — vom Rath's, Hermann's, Flemming's — have no marked superiority except for demonstrating certain glands as noted in the section on the integument. Picro-sulphuric acid has the advantage when used for very small specimens, of decalcifying the shell while leaving it *in situ*; in specimens killed in corrosive acetic the shell parts from the animal, in consequence I suppose of the pressure due to the more rapid evolution of gas brought about by the larger proportional amount of acid. An acid killing agent, as Bernard has pointed out, is desirable because it at once coagulates the mucus and thus renders the goblet cells more conspicuous.

For purposes of dissection it is desirable to have some specimens killed in formalin. The comparative transparency produced by this agent as well as its slight swelling action are often of advantage; it has the further good quality that it preserves at least for some time the color of the nephridial epithelium. A 2% solution is most satisfactory and it is of course desirable that the solution if acid should be neutralized. Opaque specimens for dissection are best killed in Gilson's fluid. It is perhaps unnecessary to add that details can often be made out better in specimens in which

the pressure on the viscera entailed by the contraction of the foot has been done away with either by removal of this organ or by slitting it lengthwise and thus opening the visceral cavity.

Sections were prepared by imbedding in paraffin, were stained usually with hæmalum and eosin or with Ranvier's picrocarmine and methylen blue, and were mounted in xylol balsam. For demonstration of mucus Mayer's mucicarmine was employed on sections of material killed in 5% sublimate solution. Endothelium was demonstrated by bathing the fresh membrane for half an hour in a mixture composed of four parts saturated aqueous solution of methylen blue and 96 parts $\frac{6}{10}$% salt solution, then leaving it for some hours in a saturated solution of ammonium picrate. Specimens thus prepared were mounted in glycerine saturated with ammonium picrate and have kept well for some years.

For macerations, good results have been obtained with Haller's fluid (*cf.* Lee's *Vademecum*, 4th ed., p. 318) and Bernard's fluid (Bernard, '90, p. 101).

Total preparations showing the innervation of thin structures like the mantle or the gill were most successful when stained with methylen blue and mounted in glycerine surcharged with ammonium picrate. Such preparations are fairly permanent.

Habits

Here should be intercalated the article on the biology of Acmæa already mentioned. To the facts there stated I have only to add that I have occasionally found in the nuchal cavities of specimens collected at Eastport tiny shells, measuring about one mm. in diameter which have been identified for me by Mr. Charles W. Johnson of Boston as in all probability the young of *Lacuna neritoidea* Gould. Whether these are commensals or merely accidental visitants I am not prepared to say.

The literature dealing with this section is incorporated in the list at the close of the present article. The statement by Dall that fertilization is internal was published not in 1879 but in 1882.

GENERAL DESCRIPTION

Acmæa testudinalis, like the limpets in general, has a somewhat dish-shaped shell, (Figs. 1 and 2), roughly conical in section and with a mouth (corresponding to the base of the cone) which is broadly oval though with the anterior part a trifle narrower than the posterior. The apex of the shell lies not over its center but about one third of the distance from the anterior end. It may be

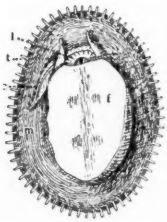

FIG. 1.

FIG. 2.

FIG. 1.— *Acmæa testudinalis*. Ventral view. × 1½. Whole animal with the exception of the mantle, strongly contracted. *c.*, ctenidium; *f.*, foot; *l.*, lip surrounding the circular mouth which is dilated to show the inner lips between which appears the dark radula; *m.*, mantle; *t.*, tentacle. Camera.

FIG. 2.— *Acmæa testudinalis*. Side view. × 1½. Camera.

worthy of mention that the true, or docoglossate limpets and the keyhole limpets (Fissurellidæ) differ in this respect from all the other widely dissimilar genera to which this form of shell is common and in which the apex, though varying in position in different forms, is never anterior. The condition in Acmæa is a secondary one for Boutan ('98, p. 1869) finds that in *A. virginea* the apex is at first posterior and only in course of development assumes the adult position.

In color the shell is usually yellowish gray marked with radiating stripes or tesselations of dark brown. The extent and the tint of the markings vary greatly and they are sometimes almost or quite absent. The hypostracum, or inner layer of the shell, stops a little short of its edge so that on the internal aspect the markings appear as a narrow border. This I understand to be the "more or less distinct internal border of the aperture," mentioned by Tryon and Pilsbry ('91, p. 5) as a character by which the Acmæidæ are

usually distinguished from the Patellidæ. While the family to which a limpet belongs may often be thus recognized, the genera at least of the Acmæidæ, cannot according to Pilsbry, be determined by a study of the shells alone.

In the living animal the mouth of the shell is almost entirely filled up by the foot, a broad fleshy expansion of the ventral body surface which apparently serves as a sucking disc[1] to hold the animal to the rocks on which it lives. The organ is composed chiefly of muscle fibers most of which run from the shell ventralward, spreading both laterally and toward the median line. A few fibers, however, are parallel with the sole and run either lengthwise or transversely. The fibers are imbedded in connective tissue and are entirely wanting near the margin of the foot, which is composed mainly of connective tissue excavated by large blood sinuses and is therefore extremely flexible. Certain marginal unicellular glands, whose secretion may aid the foot in clinging, are described, together with the epithelium in general, under the topic *Integument*. Just in front of the foot appears a ventral prolongation of the head, the muzzle; it bears on its tip the small circular mouth surrounded by the simple frill-like lip, which is characteristic of the subgenus Collisella. In a specimen which has been narcotized with chloretone the mouth is usually dilated enough to show the yellowish brown inner lips (Fig. 1) and in a fresh one its continual opening and closing permits a good view of the radula, which has a constant licking motion. It has been suggested by Davis and Fleure (:03, p. 49) that this movement serves to keep in motion the blood in the circumodontophoral sinus and thus reinforces the feeble ventricular muscles.

At the sides of the muzzle appear a pair of long and very contractile tentacles; they are borne on the posterior part of the head and each carries on the outer side of its base a simple optic pit which in the living animal or in a formalin specimen appears as a spot of black pigment.

In front of the head or at the right of the foot the ctenidium, or gill may usually be seen. When fully extended this organ is nearly

[1] This almost universally accepted view has been controverted by Davis ('95; Davis and Fleure, :03, pp. 4, 15) but the arguments do not seem to me conclusive.

one half as long as the entire animal; it is attached to the posterior wall of the nuchal cavity so that its distal end alone is visible (Fig. 3). It is a somewhat plume-like organ; the shaft of the feather is represented by a flattened triangular lamina, very long and very narrow, which bears on its flattened dorsal and ventral faces the structures corresponding to the barbs. These are two series of flattened more or less semicircular sacs each of which runs transversely across the shaft so that its cavity communicates with each of the two lateral vessels described below.

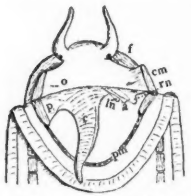

FIG. 3.— *Acmæa testudinalis*. Nuchal cavity. × 2. Columellar muscle cut and roof of chamber turned back. *a.*, anal papilla; *c.*, ctenidium; *cm.*, columellar muscle; *f.*, foot; *ln.*, *rn.*, left and right nephridial papillæ; *o.*, osphradium; *p.*, pericardium; *pm.* pallial muscle

Blood is conveyed through the gill by means of two vessels each of which occupies one margin of the shaft. That on the right edge conveys blood from the suprarenal plexus (*cf.* p. 184) to the gill, that on the left carries blood from the gill to the auricle. In the living animal the gill is usually so rotated that the efferent vessel alone is visible.

Attachment of the shell is effected by a band composed of the pallial and the columellar muscles (Fig. 4). The pallial muscle is ring-like and its fibers extend from the shell into the mantle. The columellar muscle is horseshoe-shaped and lies just internal to the pallial muscle from which it is separated by no sharp boundary; its fibers run from the shell into the foot and it is of course interrupted anteriorly where the head is interposed between these two structures.

From this muscle band depends the mantle, a thin, tentacle-fringed, membranous fold which lines the marginal part of the shell and in front of the columellar muscle runs up to the apex. In this region it forms the roof of a deep cavity, the nuchal cavity, which lies above the head and neck and is bounded at the sides and behind by the columellar muscle and the front part of the visceral mass. Elsewhere the mantle forms the outer wall of a groove-like space, the mantle groove, enclosed between it and the foot. Mantle groove and nuchal cavity are of course continuous; both together constitute the mantle cavity.

The dorsal part of the body is in the main developed into the convex visceral mass, but just above the anterior part of the foot it suddenly contracts into the neck (Fig. 2) and this, passing forward and slightly enlarging, gives rise to the head which curves ventralward and ends in the so called muzzle, thus bringing the mouth to lie flush with the foot. The head consists of a thin, muscular wall which in the region of the muzzle is fused with the pharyngeal walls but farther back is separated from them by a large blood sinus.

The visceral mass contains the digestive tract, blood vascular system, reproductive glands, and nephridia. It is covered by a green epithelium which immediately underlies the shell and may readily be brushed away. This being done, parts of all the above-mentioned organs may be made out through the thin body wall though they can be seen somewhat more readily in a specimen preserved in Gilson's fluid or formalin.

In such a preparation (Fig. 4) one notices first the band composed of pallial and columellar muscles; it is divided into a series of fascicles by blood vessels which cross it. External to the muscle ring is the mantle, fringed with its tiny tentacles and marked on the edge with a band of pigment whose alternations of light and dark tint have a general correspondence with the light and dark radial markings of the shell. In this region the mantle is thickened by the presence of a mass of unicellular glands of uncertain function. Just internal to the pigment band is a zone, often contracted to extreme narrowness, which represents the thin, non-glandular part of the mantle. Internal to the anterior curve of the pallial muscle and between the ends of the columellar muscle is a pellucid space, the roof of the nuchal cavity, in which may be noted traces of a blood plexus and through which the outlines of the ctenidium and the head may be more or less clearly seen.

Turning now to the visceral mass we note just internal to the columellar muscle and pericardium (see below) the edges of the generative gland; the bulk of the organ lies in the ventral part of the body directly above the foot, but its margins, especially the left one, curve dorsalward until they immediately underlie the nephridium through whose thin walls they are more or less clearly to be seen. Internal to the pericardium a small portion of the gland is

always distinctly visible. In the apical part of the visceral mass is the digestive gland; partly imbedded in it and partly lying between

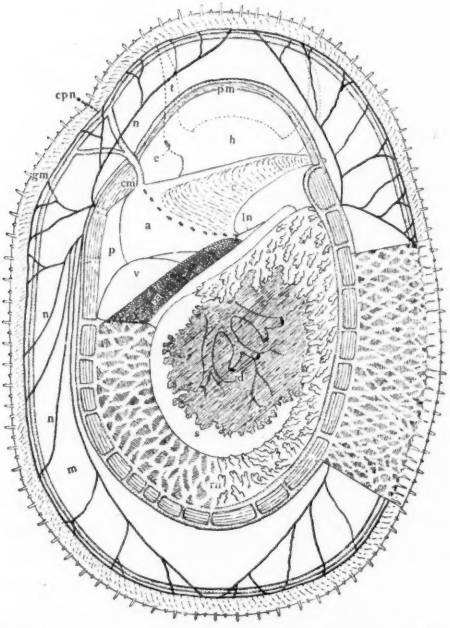

FIG. 4.— *Acmæa testudinalis*. Dorsal view with shell and superficial epithelium removed. × 4. *a.*, auricle; *c.*, ctenidium; *cm.*, columellar muscle enclosing the nuchal cavity and visceral mass; *cpn.*, circumpallial nerve ring; *d.*, digestive gland; *e.*, eye; *g.*, generative gland; *gm.*, glandular zone of mantle; *h.*, head; *ln.*, left nephridium; *n.*, mantle nerve; *p.*, pericardium; *rn.*, right nephridium, its cœca on the right half of the figure represented in profile, on the left half represented *en face* thus giving the effect of a vascular plexus; *s.*, stomach; *t.*, cephalic tentacle; *v.*, ventricle; the inner non-glandular portion of mantle is mostly represented as transparent but in a small section shows the vascular plexuses of which the ventral one underlies and obscures the external pallial vessel. The rectum, unmarked, lies between the generative gland and the right nephridium. For names of blood vessels see text. Two of the vertical interfascicular vessels are shown in dotted lines at the left; elsewhere they underlie and are obscured by the horizontal interfascicular vessels. Outlines drawn with camera, details combined from several specimens.

it and the generative gland are portions of the coiled alimentary tract especially the obliquely-running posterior end; sometimes a bit of the radula appears near the middle of the gland. On the left

side, abutting against the anterior portion of the columellar muscle is a pellucid triangular space, the pericardium. This space lies for the most part in the anterior, nearly vertical wall of the visceral sac and may in a preserved specimen of a ripe Acmæa be almost or quite hidden by the generative organ, which seems to overlie it. Such an appearance is, however, an artefact, being due to a folding of the anterior wall brought about by strong contraction. Behind the pericardium and abutting against the whole remaining extent of the columellar muscle lies the dorsal portion of the right nephridium; the ventral part of the organ occupies the right half of the ventral face of the visceral mass directly underlying the generative gland and is, of course, invisible from above. The marginal part of the dorsal nephridial wall is especially conspicuous for this is produced dorsally into numerous branched cœca that immediately underlie and are grown to the dorsal integument. Anteriorly the nephridium not only occupies the margin of the visceral sac but sends from its right limb toward the median line a large branched lobe which reaches and in part overlies the end of the intestine. On the left of the rectum between it and the pericardium, may be distinctly seen the small left nephridium, partly overlying the rectum.

The structures thus far described may, as has been stated, be made out more satisfactorily in a preserved specimen; the blood vessels now to be enumerated can be studied to much better advantage in a living animal though some of them are distinguishable in a preserved one. An Acmæa which has been kept in water of 15° to 25° C. until dead or dying is well relaxed. In such a specimen some at least of the mantle nerves may often be seen and it usually shows clearly the following vessels:—

1. Internal pallial vessel (*Mantelrandvene* or *Mantelrandarterie* of Haller), which lies just outside and beneath the pallial muscle and, like it, forms a complete ring.

2. Perivisceral vessel, a U-shaped vessel lying just inside the columellar muscle. On the right it is continued around the end of this muscle and across the pallial muscle to the internal pallial vessel; on the left it ends just behind the pericardium, where it falls into one of the horizontal interfascicular vessels.

3. External pallial vessel (pallial vein of authors), which forms

a second ring around the margin of the mantle at the base of the glandular zone.

4. The horizontal interfascicular vessels (*Quervenen* of Haller), a series of vessels which cross the columellar and pallial muscles connecting the perivisceral and the internal pallial trunks.

5. The vertical interfascicular vessels, a series of vessels which run up from the foot in the columellar muscle, join each with a horizontal interfascicular vessel and so connect with the internal pallial.

6. The mantle plexus. This consists of a dorsal and a ventral network. The vessels of the ventral network arise from the internal pallial trunk and the ultimate branches end blindly in the glandular zone. The vessels of the dorsal network arise from the external pallial trunk and end blindly in the non-glandular zone of the mantle. In a view such as we are describing the two networks are indistinguishable.

7. The transverse pallial vessels. One or two vessels, which arise from the external pallial trunk opposite the left end of the columellar muscle, unite (if two are present) and curve around the muscle to the auricle. In a relaxed specimen such as we are describing they cannot be traced to the auricle but in a perfectly fresh animal their pulsation is readily seen.

8. Indications of a suprarenal plexus (*periintestinales Venennetz* of Haller). The distal ends of the nephridial cœca are grown to the dorsal body wall and the blood sinus in which they lie is thus broken up into a series of connecting spaces.

9. Supravisceral vessels, which ramify over the dorsal surface of the digestive gland and open eventually into the suprarenal plexus. I have been most fortunate in finding these dorsal vessels showing clearly in specimens preserved in Gilson's fluid in which the contraction had been reduced to a minimum either by narcotizing with chloretone or by slitting the muscles of the foot.

10. Ctenidial vessels. In a preserved specimen one may see through the wall of the nuchal cavity the ctenidium with its dorsal series of lamellæ and the afferent and efferent vessels running respectively along its right (posterior) and left (anterior) edges. The afferent vessel brings blood from the suprarenal plexus, the efferent one carries it to the auricle. At the base of the gill may

be seen small opaque patches, the expression of interspaces between vessels that open directly into the auricle or the gill vessels. Those which open into the afferent vessel come from the anterior part of the suprarenal plexus; those which open into the auricle and the efferent vessel come from the nuchal plexus.

The nuchal cavity (Fig. 3), as has been said, lies in front of the visceral sac and above the head and neck; it is somewhat triangular in longisection and its posterior wall curves from side to side so that the cavity is much deeper from front to back in the median line than laterally. It contains the following structures, which with the exception of gill and pericardium are borne entirely on the posterior wall: pericardium with the enclosed heart, ctenidium, papillæ of small left and of large right nephridia, anal papilla. Separate generative openings are absent, as is also a hypobranchial gland.

On looking into the cavity from the front, one notices first the large ctenidium whose line of attachment runs along the mantle from the left tip of the columellar muscle obliquely back to the hinder wall of the cavity, where it ends a little on the right of the median plane. Through the thin posterior wall of the chamber can be seen the rectum lying near its dorsal edge and extending from the ctenidium almost to the right tip of the columellar muscle, where it ends upon a prominent anal papilla. Below the rectum appears a portion of the large right nephridium. It opens by a sizable papilla (infra-anal papilla of authors) located at the right of the anus. Above the rectum, in the triangle included between it, the gill, and the dorsal edge of the mantle cavity, lies the small left nephridium; it opens by an inconspicuous papilla (supra-anal papilla of authors) above and to the left of the anus. Behind and on the left of the ctenidium is a large triangular space enclosed between it and the columellar muscle and lying partly in the posterior and partly in the dorsal wall; this is the pericardium. The osphradia are so inconspicuous as to be readily overlooked; they are a pair of narrow transverse epithelial ridges which lie on the neck a little behind the anterior end of the columellar muscle. In a specimen whose shell was 35 mm. in length the left osphradium was 2 mm. long and the right 1.5 mm. According to Dall these structures are sometimes rendered conspicuous by an orange pigment; I have never seen such specimens.

Previous Investigations.—No extended account of the external anatomy of Acmæa has hitherto been published; the fullest description is embodied in a single paragraph by Forbes and Hanley ('53, p. 436). Haller's description of the mantle and gill will be discussed in subsequent sections.

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AFFINITIES OF CERTAIN CRETACEOUS PLANT REMAINS COMMONLY REFERRED TO THE GENERA DAMMARA AND BRACHYPHYLLUM[1]

ARTHUR HOLLICK AND EDWARD C. JEFFREY

Introduction

This paper is a preliminary contribution, designed to demonstrate the value of critical examinations of palæobotanical material by means of the microscope. The results obtained by such examinations of three kinds of Cretaceous fossil plant remains are described, *viz.*: cone scales commonly referred to the living genus Dammara, leafy branches commonly referred to the extinct Coniferous genus Brachyphyllum, whose exact botanical affinities have not heretofore been satisfactorily determined, and certain lignitic fragments found associated with the foregoing.

The first mentioned are shown to belong not to Dammara but to an extinct genus, closely related to it, to which the new generic name Protodammara is given. The second are shown to be Araucarinean in their affinities and probably to represent the branches of the tree which bore the cones from which the scales of Protodammara were derived. The third are shown to be referable to Araucarioxylon and probably to represent the wood of the tree which bore the leaves of Brachyphyllum and the cones of Protodammara.

[1] Read before the Botanical Society of America, New Orleans meeting, January 4, 1906.

Contributions from the Phanerogamic Laboratories of Harvard University. — No. 4.

Contributions from the New York Botanical Garden.— No. 79.

DISCOVERIES WHICH SUGGESTED THE PREPARATION OF THIS PAPER

The discoveries which suggested the preparation of this paper were described in a previous paper read before the Botanical Society of America at the Philadelphia meeting, on December 30th, 1904.[1] During the autumn of that year an interesting section of Cretaceous deposits was found exposed in the Androvette clay pit, at Kreischerville, Staten Island, N. Y. At this locality the deposits consist of irregularly stratified sands and clays, in one part of which occurs a lens-shaped bed of closely packed vegetable *débris*, consisting of leaves, cone scales, twigs, amber, charred wood, and lignite. At that time special attention was given to the amber and the other remains were merely examined superficially and briefly mentioned. The suggestion was made by Dr. Jeffrey that critical examination of the lignitic fragments would probably produce interesting results, and this suggestion led to two joint visits to Kreischerville during the past year and the collection of a large amount of new material, in part from the original locality and the remainder from the nearby Drummond pit. Some of the results obtained from the examination of this material form the basis of this contribution.

OBJECT AND SCOPE OF THE INVESTIGATION

One of the great difficulties in connection with any attempt to determine satisfactorily the relationships of palæobotanical specimens is due to the fact that such specimens are nearly always more or less fragmentary, being represented only by dismembered parts or organs of plants, and seldom or never by a complete individual organism. Under such conditions it is not surprising that descriptions based upon superficial characters only have frequently resulted in erroneous generic determinations; different parts of the same species have often been described under two or more specific or generic names; or occasionally a single specific

[1] Arthur Hollick. "The Occurrence and Origin of Amber in the Eastern United States." Published in *Amer. Nat.*, vol. 29, pp. 137–145, *pls. 1–3*, 1905.

name was made to include several different fragments which were subsequently ascertained to belong to two or more distinct species.

The identification or determination of a genus solely from the shape or superficial markings of a cone or some of its detached scales or of a leaf or a leafy twig, can seldom be entirely conclusive or satisfactory; but it may be readily appreciated that if, in addition, the internal structure of such specimens can be made out by the use of the microscope, not only may the genera be thus determined beyond question, but many fragmentary scattered remains, presenting no superficial characters of any diagnostic value, might thus be identified and brought together into their true generic and specific relationships.

Superficial examination of the Kreischerville material showed that it contained a number of recognized species, descriptions of which were based upon well defined external characters, besides quantities of specimens which were not identifiable by ordinary means. This indicated a specially favorable field for investigation, of which advantage was taken, and the methods employed, together with some of the selected results obtained, are here described.

Description of the Gross Material

Botanical Characters of the Plant Remains.— A rough examination of the gross material showed the presence of pteridophytes, angiosperms, and gymnosperms. The remains of the pteridophytes were exceedingly fragmentary and unsatisfactory. Those of the angiosperms consisted for the most part of dicotyledonous leaf impressions in the clay, usually accompanied by a thin film of carbonaceous matter, which generally disappeared on exposure to the air.

The remains of the gymnosperms proved to be more satisfactory, however, being represented not only by isolated coniferous leaves which retained more or less of the substance of the plant, but also by leafy twigs and branches, cones and cone scales, and fragments and logs of lignite, some of which contained amber in their interstices. Special attention was therefore given to these remains amongst which specimens of the following genera and species were separated out and identified.

List of the Coniferous Remains

1. Cone scales, allied to Dammara and similar to very small specimens of *D. microlepis* Heer. These are described in this paper on p. 199 under the new generic name Protodammara.

2. Cone scales and leaves of *Pinus* sp. The scales are relatively small. Several of the leaf specimens showed three in a bundle, enclosed in a sheath.

3. Leafy twigs of *Sequoia reichenbachi* (Gein.) Heer, *S. heterophylla* Vel., *Juniperus hypnoides* Heer, *Widdringtonites reichii* (Etts.) Heer, *Frenelopsis gracilis* Newb., and *Brachyphyllum macrocarpum* Newb.

4. Lignite and other fragmentary coniferous remains which could not be generically determined from their external characters.

5. Amber, occasionally in the interstices of the lignites, but for the most part in the form of small drops or "tears" and irregular fragments.

METHODS EMPLOYED IN THE CRITICAL EXAMINATION OF THE MATERIAL

Maceration and Separation of the Gross Material.—In the examination of the finer vegetable *débris* previously described the following method was employed. Caustic soda or potash in 1 to 3% solution was used with considerable success. After this treatment the fragments of plants were somewhat swollen and separated readily from one another and from the argillaceous matrix. The loosened clay was washed away on a wire gauze tray of not too fine meshwork and the lignitic or carbonaceous fragments were left in a clean and recognizable condition. The fragments in most cases were rather small, especially those of greatest interest, so that the most convenient method of recognition was by means of a dissecting microscope of very low magnification. A great many different kinds of coniferous remains were thus separated out and identified from their external appearance, as well as many charred specimens of dicotyledonous woods. Of these in general no account will be given at the present time, for attention was restricted to the cone scales similar to those referred by Heer to the genus Dammara, leafy branches belonging to the Brongniartian genus Brachyphyllum, and certain Araucarineous lignites. The chosen material was often in a very

good state of preservation especially when charred, or partially charred.

Sectioning and Microscopic Examination of Specimens.— In the case of lignitic or charred vegetable remains it is necessary for successful study to obtain very thin sections, on account of the dark color and opacity of the fossilized tissues. By the use of hydrofluoric acid for removing mineral matter and by embedding in thickened celloidin, it was found possible to make sections often of large area, as thin as 5 micra which proved admirable for photomicrographic purposes. These sections were cleared at once in benzole without previous staining, since the natural dark color of the lignites was sufficiently pronounced to differentiate the structures, even in very thin sections. In some cases it was found necessary to reduce the natural dark hue of the preparations and chlorine water was useful for this purpose. The sections were mounted in balsam on plate-glass slides and after previous drying were subjected to pressure and high temperature in the warm oven for the purpose of making them perfectly flat. All the photomicrographs in the present article were made by means of Zeiss lenses, except those showing surface features. The latter were executed with the admirable Heliar lenses of the Spencer Lens Co. Electric light was employed in all cases as the illuminant.

Descriptions of Specimens

Cone Scales Commonly Referred to Dammara. — Fossil cone scales similar to ours were described and figured for the first time by Professor Edward Hitchcock,[1] in his account of the organic remains found at Gay Head, Martha's Vineyard. They were not named by him, but his figures and description leave little to be desired. He says: "Figs. 4, and 5, represent different individuals of another variety of vegetable remains.... These are not mere impressions; but a scale of carbonaceous matter, mixed with amber, marks the spot where the vegetable was imprisoned.... It seems to me very obvious that these remains must be the seed vessels of some coniferous plants."

[1] *Final Rept. Geol. Mass.*, vol. 2, p. 430, *pl. 19, figs. 4, 5*, 1841.

It was not until many years after Hitchcock's description was published that any further discovery of similar remains was made, or at least recorded, and to Professor Oswald Heer belongs the credit of first recognizing their affinities with the living Coniferous genus Dammara, in his description of specimens identical with those from Gay Head, under the name *D. borealis*,[1] from the Cretaceous of Greenland, in his discussion of which he says (p. 55): "Es haben diese Schuppen so grosse Aehnlichkeit mit derjenigen von Dammara (Agathis), dass wir sie derselben Gattung zutheilen dürfen." For purposes of comparison a figure of this species, representing a specimen collected at Gay Head, is shown on Plate 1, Fig. 1.

Two other so called species were also described and figured by the same author, *viz.*: *D. microlepis*[2] and *D. macrosperma*.[3] A specimen of the former, collected at the Gay Head locality, is shown on Plate 1, Fig. 2, which, by comparison, may be seen to differ from *D. borealis* merely in size. *D. macrosperma* has not been recognized in any collection of material except that from Greenland, and it is doubtful if it should be regarded as specifically distinct from the other two. In other words all three of these so called species might very well be included under *D. borealis*.

Heer was evidently in considerable doubt in regard to the identity of some of his specimens and also with regard to their botanical relationships. In his discussion of *D. microlepis* for example he says (p. 55, *loc. cit.*): "Hat einige Aehnlichkeit mit den Blüthenknospen des Eucalyptus Geinitzi," and a comparison with the figures of the objects which he refers to the fruit of that species[4] shows them to be so closely similar in appearance to his Dammara scales as to be practically indistinguishable from them.

Krasser, Beyer, and Velenovsky subsequently described and figured similar remains from the Cretaceous of Europe, with varying opinions as to their probable botanical affinities. The last

[1] *Fl. Foss. Arct.*, vol. 6, pt. 2, p. 54, *pl. 37, fig. 5*, 1882.
[2] *Ibid.*, p. 55, *pl. 40, fig. 5*.
[3] *Ibid.*, vol. 7, p. 17, *pl. 53, fig. 11*, 1883.
[4] *Ibid.*, vol. 6, pt. 2, p. 93, *pl. 45, figs. 4–9*, 1882.

author first referred them to *Eucalyptus geinitzi* Heer,[1] with the leaves of which species they were found closely associated, but later he called what are evidently identical remains *Dammara borealis* Heer.[2]

In 1889, Mr. David White visited Gay Head, and in the following year, in a paper "On Cretaceous Plants from Martha's Vineyard"[3] he described and figured specimens collected there, referring to them as follows (pp. 98, 99): "Next to the preceding species, the most numerous of the plants from Gay Head is *Eucalyptus Geinitzi* Hr., fig. 8–11, two of whose fruits, 'resembling unopened flowers of syngenesian plants,' were figured as 'scales of vegetable remains' in Hitchcock's Final Report. This species, first described from the Liriodendron beds (Middle Cretaceous) of Greenland, is abundant in and most characteristic of the Middle Cretaceous of Bohemia, and is also present in the same stage (Cenomanian) in Moravia. The specimen, fig. 11, is included here on account of its coincidence with one figured by Velenovsky (Foss. Flor. böhm. Kreide., iv, pl. xxv, fig. 7), which he supposed represented a flower of this species. It may belong to a conifer.

"The remains of the nuts show longitudinal furrows (white in the figures) filled with a resin which is 'indistinguishable by ordinary tests from Amber,' and which was observed and pronounced amber by Hitchcock in 1841. These doubtless are the remains of gum or oil vessels, such as exist in the nuts of recent Eucalypts; and the granules of 'amber' can hardly be else than Eucalyptus gum.

"The explanation is at once suggested that the fragments of amber observed by various writers, during the last hundred years, about Gay Head, and in the New Jersey Cretaceous, where also Eucalypts are found, are the product of the contemporaneous 'gum-trees,' rather than of some conifer. None of this American amber has, I believe, been tested for succinic acid, or to show its relation to true amber."

[1] *Foss. Fl. Böhm. Kreideform.*, pt. 4, p. 1 [62], *pl. 1* [*24*], *figs. 1, 2; pl. 2* [*25*], *figs. 6–11; pl. 4* [*27*], *fig. 13 in part*, 1885.

[2] *Kvet. Cesk. Cenomanu*, p. 7, *pl. 1, figs. 28, 29*, 1889.

[3] *Amer. Journ. Sci.*, vol. 39, p. 93–101, *pl. 2*, 1890.

At about this same time Dr. J. S. Newberry was engaged in the investigation of the Cretaceous flora of New Jersey, the results of which were later included in his "Flora of the Amboy Clays."[1] In this work he lists *Dammara borealis* Heer as a characteristic and abundant element of the flora, and says (pp. 46, 47): "In his Flora Fossilis Arctica (loc. cit.) Professor Heer describes and figures the scales of a conifer which very much resemble those of *Dammara australis*, and yet there are some reasons for doubting the accuracy of his reference. It may also be said that the fruit scales which he calls *Eucalyptus Geinitzi*. . . . are without doubt generically the same. . . . the fruits figured by Heer under the name of Eucalyptus are plainly scales, and are parts of an imbricated cone. I say this with confidence, because it has happened that in the Amboy clays we have found numbers of them sometimes associated together, oftener scattered and showing both faces. A peculiarity of these scales is that they are striped longitudinally by clefts which are filled with an amber-like substance. This structure is plainly seen in those figured by Professor Heer on Pl. XLV. Similar scales are described in an article by Mr. David White on the fossil plants from Gay Head. . . .

"The considerations which have led me to doubt whether these cone scales are those of Dammara are that we have found no Dammara-like leaves associated with them, whereas in New Jersey they occur in great numbers mingled with and sometimes apparently attached to the branchlets of an extremely delicate conifer much like Heer's *Juniperus macilenta*. . . . Almost no other plant except this conifer is found with the cone scales, and it is difficult to avoid the conclusion that they belong together. Another reason for doubting whether these are the scales of a Dammara is that in some of them traces of two seeds are apparently visible, while in Dammara there is but one seed under each scale."[2]

The discussion is further continued by Dr. Newberry under his

[1] *Monogr. U. S. Geol. Surv.*, vol. 26, 1895.

[2] This observation by Dr. Newberry is particularly interesting in the light of what we now know in regard to the Kreischerville specimens, as may be appreciated by referring to our description of the seed scars on those scales, on p. 199.

description of *Juniperus macilenta*, on pp. 54, 55 (*loc. cit.*), as follows: "Thickly scattered among the twigs there are cone scales and cones .... The cone scales are evidently identical with those described by Heer under the name of *Dammara microlepis*.... and probably with those described by him as *Dammara borealis*." He says, however, that they cannot belong either to *Dammara* or to *Juniperus* and finally concludes with the hope "that in the future material will be obtained that will enable us to reconstruct this tree and determine with accuracy its botanical relations."

Dr. Newberry again refers to the scales in connection with his discussion of *Eucalyptus? angustifolia*, in the following words (*ibid.*, p. 111): "Professor Heer feels strengthened in his reference of leaves having this nervation to Eucalyptus by finding in company with them what he regards as the fruit of Eucalyptus; but in my judgment the examples he gives of this fruit....are rather detached scales of the cone of some conifer, and probably generically identical with the cone scales which he has called *Dammara borealis*."

Some years ago the senior writer of this paper began an investigation of the Cretaceous flora of the Atlantic coastal plain, and in the material collected in New Jersey and on Staten Island, Long Island, Block Island, and Martha's Vineyard, numerous specimens of cone scales were found, some of them unquestionably identical with *Dammara borealis* or *D. microlepis* as defined by Heer, and others which apparently represented new species. Following are references to the specimens in question:—

"*Dammara borealis*, Heer?" Tottenville, Staten Island. *Trans. N. Y. Acad. Sci.*, vol. 12, p. 31, *pl. 1, fig. 17*, 1892.

"*Dammara borealis*, Heer." Chappaquidick, Martha's Vineyard. *Bull. N. Y. Bot. Gard.*, vol. 2, p. 402, *pl. 41, fig. 6*, 1902.

"*Dammara microlepis* Heer (?)." Ball's Point, Block Island. *Ann. N. Y. Acad. Sci.*, vol. 11, p. 57, *pl. 3, figs. 9 a, b*, 1898. At the time when these two specimens were described they were only referred provisionally to this species, in the following words: "The ones under consideration are, however, smaller than any which have been previously figured and might perhaps be referred to a new species, but in view of the limited amount of material and its fragmentary condition, I have thought it best to refer the speci-

mens provisionally to Heer's species." I am now satisfied that they belong to the new genus and species hereafter described and they are included, for comparison, on Plate 1, Figs. 12, 13.

"*Dammara Northportensis* sp. nov." Little Neck, Northport Harbor, Long Island. *Bull. N. Y. Bot. Gard.*, vol. 3, p. 405, *pl. 70, figs. 1, 2*, 1904. A figure of this species is reproduced on Plate 1, Fig. 4.

"*Dammara (?) Cliffwoodensis* n. sp." Cliffwood, N. J. *Trans. N. Y. Acad. Sci.*, vol. 16, p. 128, *pl. 11, figs. 5–8*, 1897. A figure of the type specimen of this species is reproduced on Plate 1, Fig. 3. This species may also be found described and figured by Mr. Edward W. Berry in his "Flora of the Matawan Formation (Crosswick's Clays)," [1] and again in a subsequent paper on "Additions to the Flora of the Matawan Formation"; [2] but the figures more nearly resemble *D. borealis* than they do the species to which they are referred, and the author himself remarks, in regard to the one last mentioned (p. 70): "'The specimen is an unusually perfect one.... In outline and size it is very similar to the scale from Tottenville referred by Hollick to *Dammara borealis* Heer."

Finally may be mentioned the species described and figured by Dr. F. H. Knowlton, under the name *Dammara acicularis*, in his "Fossil Plants of the Judith River Beds," [3] which differs from all the other species in the possession of a well defined apical awn or spine, although in many of our individual specimens a similar feature, of smaller size, is present, and in others its former presence is clearly indicated.

If all the opinions expressed by the authors in the papers quoted, are analyzed it may be seen that a majority favor the idea that the scales are Coniferous and that their relationships are with *Dammara*, or with some other genus closely allied to it. Whether more than one species is represented in the various forms that have been described as such is a problem which yet remains to be solved and its solution will doubtless be attended with more or less difficulty, but the identification of the genus to which each form belongs should be a comparatively easy task, provided the

[1] *Bull. N. Y. Bot. Gard.*, vol. 3, p. 61, *pl. 48, figs. 8–11*, 1903.
[2] *Bull. Torrey Bot. Club*, vol. 31, p. 69, *pl. 1, fig. 11*, 1904.
[3] *Bull. U. S. Geol. Surv.*, no. 257, p. 134, *pl. 15, figs. 2–5*, 1905.

material available for study is such that it can be sectioned and subjected to critical examination under the microscope. Thus far the only specimens which we have so examined are those from Kreischerville, but it is hoped that the investigation may be continued in the future so as to include specimens from other localities.

Protodammara speciosa n. gen. et sp.

Plate 1, Figs. 5–13; Plate 2, Figs. 1–5

"*Dammara microlepis* Heer (?)." Hollick, *Ann. N. Y. Acad. Sci.*, vol. 11, p. 57, *pl.* 3, *figs.* 9 *a*, *b*, 1898.

Organisms consisting of kite-shaped cone scales, from 4 to 6 mm. long by 4 to 6 mm. broad above, abruptly narrowed from about the middle to the base, rounded, incurved, and apiculate above; resin ducts five or more, extending down the lower surface of the limb; seed scars three in number, crescentically arranged above the middle and approximately in the broadest part of the scale, with the central one higher up than the laterals.

Plate 1, Figs. 5–13, shows the scales natural size; Plate 2, Figs. 1 a, b, c, 2, shows four specimens with the upper surfaces exposed, magnified about ten diameters. Although they may be seen to resemble closely those of a small female cone of Dammara they are distinguished from the scales of that genus by the apical process and by the fact that they obviously bore three seeds instead of only one. It might indeed be inferred, from the presence of three apically attached ovules, that we have here to do with cone scales of one of the Sequoiineæ, rather than with one of the Araucarineæ, but the internal structure shows that they are truly Araucarian.

Plate 2, Fig. 3, represents a transverse section of the base of a scale, magnified about 40 times. A little below the middle point may be seen a single small fibrovascular bundle. At a higher plane of section this separates off a single upper bundle of inverted orientation and gives off a number of lateral bundles to the lower surface of the scale. The upper bundle supplies the seeds. In the higher part of the scale the inferior bundles are surrounded

by a dense cordon of transfusion tissue. The arrangement of the bundles of the scale presents throughout a close resemblance to that found in Dammara.

Plate 2, Fig. 4, represents about half of a transverse section of a scale, magnified about 50 times. The funicular attachment of one of the lateral seeds may be seen on the upper surface of the scale.

Plate 2, Fig. 5, shows a longitudinal section through the apex of the scale, which at the same time is also nearly median, magnified about 40 times.

There can be no doubt that these scales are Araucarian and that while they resemble the genus Dammara they do not belong to it. We have therefore proposed for them the generic appellation Protodammara.

Formation and Locality: Cretaceous clays, Raritan Formation. Pl. 1, Figs. 5–11 and Pl. 2, Figs. 1 a, b, c, 2, Kreischerville, Staten Island, N. Y.; Pl. 1, Figs. 12, 13, Ball's Point, Block Island, R. I.

Leafy Branches Commonly Referred to Brachyphyllum.— This genus was based upon the external characters of certain leafy branches, of Jurassic age, and was described under the noncommittal heading "Conifère douteuse." The type of the genus is *B. mamillare* Brongt., which he described but did not figure.[1] The species was figured by subsequent authorities however, notably by Saporta,[2] one of whose illustrations (fig. 4, *loc. cit.*), is reproduced on Plate 1, Fig. 14. A number of other species have also been described under the genus and under the closely related or synonymous genera Echinostrobus, Arthrotaxites, Thuites, Palæocyparis, etc. By some authors these genera have been all included under Brachyphyllum and by others they have either been regarded as distinct or else they have been grouped in various combinations. Their true botanical relationships, however, were never satisfactorily determined, although they were generally considered as allied to the Sequoiineæ or the Cupressineæ and as related to Arthrotaxis, Thuja, or Glyptostrobus. The species

[1] *Prod. Hist. Veg. Foss.*, p. 109, 1828.
[2] *Plantes Jurassiques*, vol. 3, *pl. 34, figs. 3–7*, 1884.

described by the earlier authors were all from Jurassic horizons but subsequently species were described from the Cretaceous,[1] and it is with these that we are especially concerned.

The question of generic identity between the several allied forms does not, however, come within the scope of this paper. The only matter which is of immediate concern is the fact that we have found at Kreischerville the leafy branches of a Brachyphyllum and have been able to determine, for the first time, by means of its internal structure, the exact relationship which it bears to certain living Coniferæ. This species is the same so far as external characters are concerned, as that described by Newberry from the Amboy clays of New Jersey (*B. macrocarpum* Newb., *loc. cit.*), and it has also been found at Northport, Long Island, and at Cliffwood, N. J. A reproduction of Newberry's fig. 1 (*loc. cit.*) is shown on Plate 1, Fig. 15, and the Northport specimens on the same plate, Figs. 16, 17. These are all natural size.

Plate 3, Figs. 1 a, b, c, shows three fragments of branches from Kreischerville, magnified about 6 times, and Fig. 2, on the same plate, shows one magnified about 10 times.

Plate 3, Fig. 3, shows a piece of another branch magnified about the same as the latter, and illustrates particularly well the longitudinal converging striæ characteristic of the leaves of Brachyphyllum.

Plate 3, Fig. 4, represents a transverse section through a relatively old branch, magnified by 8, in which the woody cylinder is well developed. The pith has largely collapsed, although it consists in large part of sclerotic cells.

Plate 3, Fig. 5, shows a transverse section of a young branch, magnified by 15. Four leaves may be seen on the margins of the figure, and of these, those on the broad upper and lower surfaces of the branch overlap those on the margins, as they are cut through at a higher region. The leaves are attached to the surface of the stem by practically all of their ventral surface, with only a very

[1] *Echinostrobus squamosus* Vel., *Gymnosp. Böhm. Kreideform.*, p. 16, *pl. 6, figs. 3, 6–8*, 1885; *Thuites crassus* Lesq., *Cret. and Tert. Fl.*, p. 32, 1883; *Brachyphyllum macrocarpum* Newb., "Fl. Amboy Clays" (*Monogr. U. S. Geol. Surv.*, vol. 26), p. 51, footnote, *pl. 7, figs. 1, 2, 5, 7*, 1895.

narrow border left free, where in their upper portions they overlap their neighbors. The anatomical features cannot be made out in this section as the magnification is not sufficient.

Plate 4, Fig. 1, shows a transverse section through the woody cylinder of the younger branch shown on Plate 3, Fig. 5. By using a lens it may be seen that at this stage the cylinder consists of clearly separated bundles. On the right a single leaf-trace is passing off.

Plate 4, Fig. 2, reproduces a cross section of the basal portion of a leaf from the margin of the same young branch. It may be seen that there are several fibrovascular bundles present. These have originated from the single trace previously described. Of the Cupressineæ, Sequoiineæ, and Araucarineæ, the only Conifers with which Brachyphyllum has ever been placed, *the latter group alone have the branched leaf-trace.*

Plate 4, Fig. 3, shows a similarly branching leaf-trace from one of the broad leaves which clothe the upper and lower surfaces of the stem in the genus Brachyphyllum.

Plate 4, Fig. 4, shows a portion of the latter under a higher degree of magnification. The lower fibrovascular tissue is obviously dividing into three branches.

Plate 4, Fig. 5, is part of a branch of Brachyphyllum in transverse section. The light spaces are the sections of resin-canals. Although the material was passed through a number of solvents of resin, used in a hot condition, there is still some matter present in the lumina of the resin-passages. This appears to be of a mucilaginous nature *and is comparable to that found among living Conifers only in the genera Araucaria and Dammara.*

Plate 4, Fig. 6, shows a transverse section of a diseased branch of Brachyphyllum, in which there is one particularly large resin-cavity. The fossil mucilage, as we consider it to be, is present also in this instance. We have, in fact, found this substance to be always present in Brachyphyllum, except in charred branches, and those which had become very rotten in the process of fossilization. *The mucilaginous contents of the resin-canals afford another reason for associating Brachyphyllum with the Araucarineæ rather than with the Cupressineæ or the Sequoiineæ.*

The most important argument, however, in favor of the Arau-

carineous nature of Brachyphyllum is the structure of the wood and phloëm. Plate 5, Fig. 1, is a longitudinal radial section of the tracheids of the wood, highly magnified. *They show the flattened and alternating bordered pits, which are the diagnostic feature of Araucarioxylon Kraus.*

Plate 5, Fig. 2, makes the diagnosis beyond dispute, as *it shows the very striking Araucarineous character of the rays.* Plate 5, Fig. 3, represents a transverse section through the xylem and phloëm in a yearling branch. Plate 5, Fig. 4, shows two bundles in the young stem of Brachyphyllum. It may be seen that *the region of the phloëm is marked by the absence of the regularly alternating rows of hard bast-fibers, which are found without exception in the phloëm of all Cupressineous and Sequoiineous Conifers.*

Lignites Referable to Araucarioxylon.— Associated with the cone scales of Protodammara and with the leafy branches of Brachyphyllum are found numerous specimens of lignite, amongst which are two types of Araucarioxylon. The first of these is very similar to the wood of the living Dammara, and like Dammara it is characterized by the presence of resinous tracheids. The pith, when present, is seen to be large and composed mainly of tanniferous cells as in that genus. When wounded the wood of this Araucarioxylon does not give rise to traumatic resin-canals.

The second type, so far as we have been able to observe, does not possess resinous tracheids. The pith, when present, is sclerified and of small size as in Brachyphyllum. The wood, when injured, forms resin-canals of a traumatic character.

Plate 5, Fig. 5, shows a row of traumatic resin-canals in this species. Plate 5, Fig. 6, shows one of these resin-canals and the adjacent wood, highly magnified. The tracheids of the wood are seen to be free from resin. *This type of Araucarioxylon appears to be the wood of Brachyphyllum,* while the type first described appears to belong to Araucarian Conifers more nearly allied in structure to those now in existence.

CONCLUSIONS

The cone-scales referred by Heer to Dammara, at least in the case of those from Kreischerville, do not belong to that genus but to the hitherto unrecognized Araucarinean genus Protodammara.

The leafy shoots and branches from several eastern American Cretaceous beds referred by various authors to Brachyphyllum[1] are of Araucarian affinities, as shown by their structure and as indicated by their constant association with the cone scales of Protodammara.

A large part of the lignites associated with both the above are Araucarineous and probably represent in part the wood of the trees which bore the leafy branches of Brachyphyllum and the cones of Protodammara.

The latter genus was in all probability the last survivor of an ancient Araucarian line of descent, joined near its base with the primitive stocks of the Abietineous and Cupressineous series. Its anatomical characters show that it was forced to occupy less advantageous situations in Cretaceous times, and possibly in earlier periods as well. It may have grown on dry hills, while the better adapted related forms, which still survive in the modern genera Araucaria and Dammara, flourished in the richer lowlands, in company with other gymnosperms of higher type of development and with the angiosperms, which even then had begun to assume the predominant position which they occupy to-day.

[1] We do not consider it by any means proved, that all the leafy branches of the type of Brachyphyllum are necessarily Araucarian. It appears not improbable that some of the shoots of this general type may belong to other families of the Conifers. This for example may well be the case with some Coniferous remains recently described by M. Zeiller, from the upper Lias of Madagascar and referred to Sequoiineous affinities. In this instance the cones were found attached to the branches and the author remarks that the superior portion of the cone scale terminates "en une pointe obtusement aigue", a somewhat suspicious feature of resemblance to our Protodammara.

PLATE 1

FIG. 1.— *Dammara borealis* Heer, natural size. Gay Head, Martha's Vineyard, Mass.

FIG. 2.— *Dammara microlepis* Heer, natural size. Gay Head, Martha's Vineyard, Mass.

FIG. 3.— *Dammara cliffwoodensis* Hollick, natural size. Cliffwood, N. J.

FIG. 4.— *Dammara northportensis* Hollick, natural size. Little Neck, Northport Harbor, Long Island, N. Y.

FIGS. 5–13.— *Protodammara speciosa* n. gen. et sp., natural size. Figs. 5–11, Kreischerville, Staten Island, N. Y.; Figs. 12, 13, Ball's Point, Block Island, R. I.

FIG. 14.— *Brachyphyllum mamillare* Brongt. (after Saporta), natural size.

FIG. 15.— *Brachyphyllum macrocarpum* Newb., natural size. South Amboy, N. J.

FIGS. 16, 17.— *Brachyphyllum macrocarpum* Newb., natural size. Little Neck, Northport Harbor, Long Island, N. Y.

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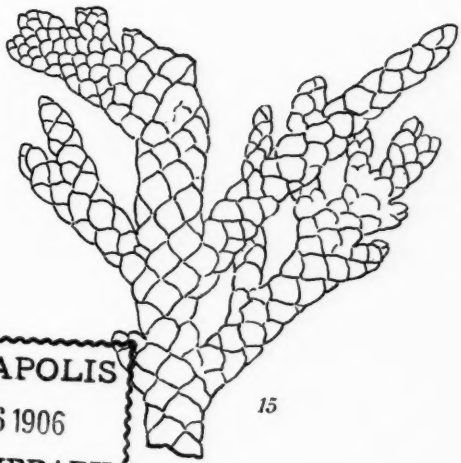

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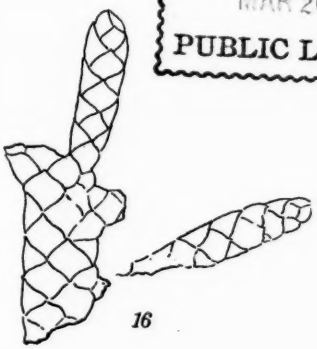

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PLATE 2

FIGS. 1–5.— *Protodammara speciosa* n. gen. et sp., enlarged. Kreischerville, Staten Island, N. Y.

Figs. 1 a, b, c, 2.— Upper surface of cone scales, × 10, or more.

Fig. 3.— Transverse section of the base of a scale, × about 40.

Fig. 4.— About half of a transverse section of a scale, × 50.

Fig. 5.— Longitudinal section through the apex of a scale, × 40.

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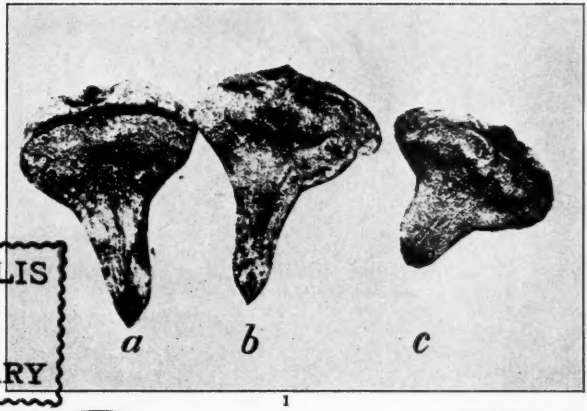

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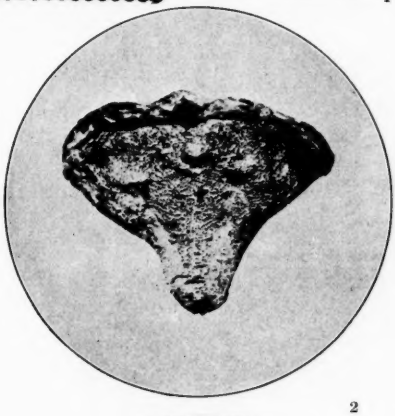

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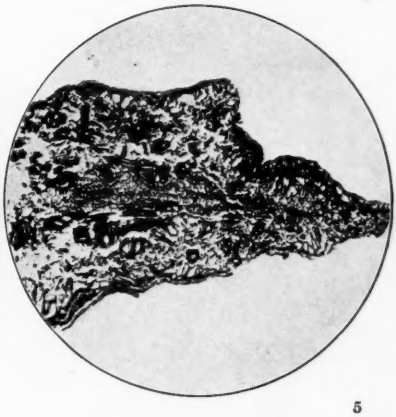

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PLATE 3

FIGS. 1–5.— *Brachyphyllum macrocarpum* Newb., enlarged. Kreischerville, Staten Island, N. Y.
Figs. 1 a, b, c.— × about 6.
Figs. 2, 3.— × about 10.
Fig. 4.— Transverse section through a relatively old branch, × 8.
Fig. 5.— Transverse section through a young branch, × 15.

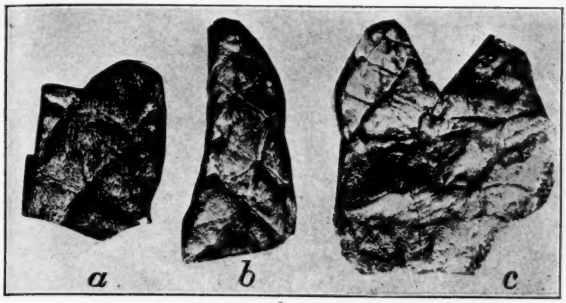

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PLATE 4

FIGS. 1–6.— *Brachyphyllum macrocarpum* Newb., enlarged. Kreischerville, Staten Island, N. Y.

Fig. 1.— Transverse section through the young woody cylinder of the branch shown on Plate 3, Fig. 5.

Fig. 2.— Cross section of the basal portion of a leaf from the margin of the same, × 50.

Fig. 3.— Same, showing a branching leaf trace, × 50.

Fig. 4.— More highly magnified, × 70.

Fig. 5.— Transverse section of a branch, showing resin-canals, × 30.

Fig. 6.— Transverse section of a diseased branch, showing a particularly large resin-canal, × 30.

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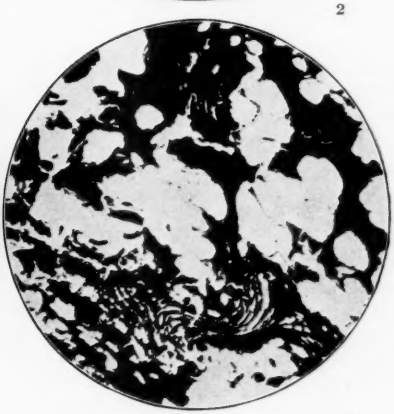

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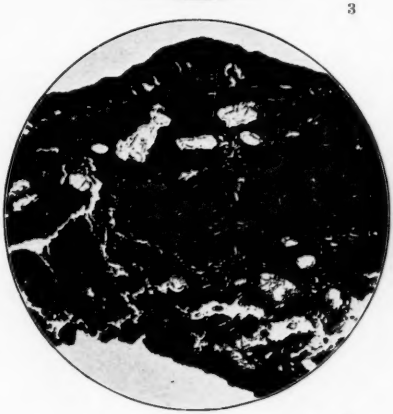

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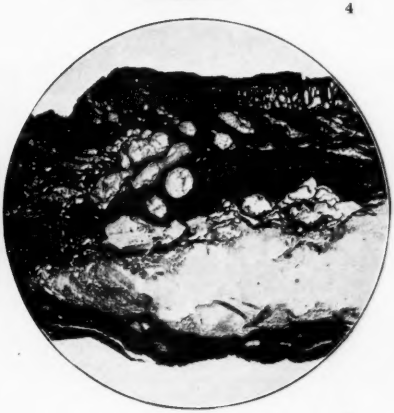

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PLATE 5

FIGS. 1–4.— *Brachyphyllum macrocarpum* Newb., enlarged. Kreischerville, Staten Island, N. Y

Fig. 1.— Longitudinal radial section showing the radial pits of the tracheids, × 200.

Fig. 2.— Medullary ray showing the characteristic Araucarian lateral pits of the ray cells, × 200.

Fig. 3.— Transverse section of the xylem and phloëm in a yearling branch, × 200.

Fig. 4.— Transverse section of a young branch showing the xylem and phloëm, × 200.

FIGS. 5, 6.— *Araucarioxylon* sp., enlarged. Kreischerville, Staten Island, N. Y.

Fig. 5.— Transverse section of injured wood, × 50.

Fig. 6.— One of the traumatic resin canals of the same, × 150.

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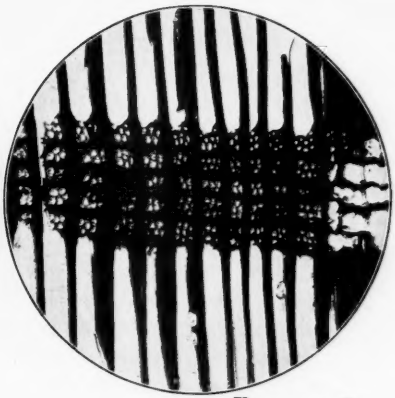

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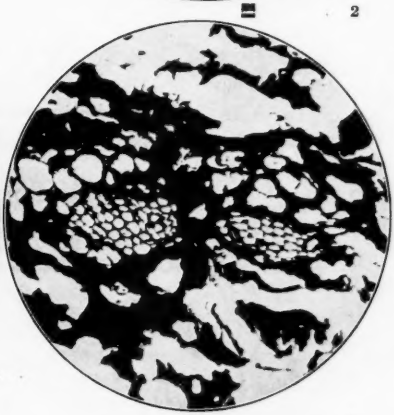

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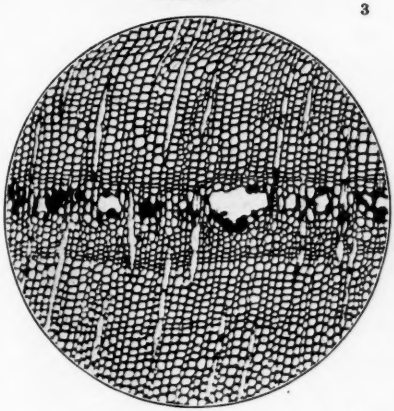

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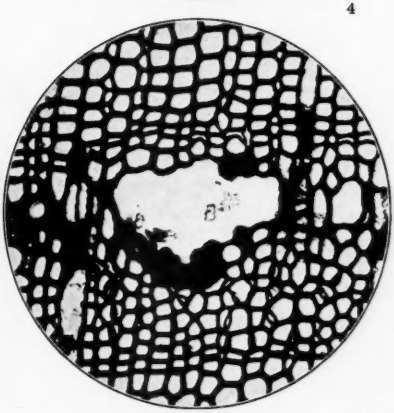

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A NEW PYCNOGONID FROM THE BAHAMAS

LEON J. COLE

Mr. Thomas Barbour has kindly turned over to me for examination a single pycnogonid taken upon the expedition made by himself, in company with Dr. G. M. Allen and Mr. Owen Bryant, to the Bahama Islands in the summer of 1904. A general narrative of their cruise has been published privately by Allen and Barbour (:04). The present paper constitutes the seventh of a series based upon the specimens collected by them.

It would appear from the fact that only a single pycnogonid was taken during this trip, and that none has been reported from the collections of previous scientific expeditions to the same region, that this group must be poorly represented in the waters contiguous to the Bahamas. And in this connection it is interesting to note that the specimen under consideration belongs without doubt, in its systematic relationships, with two species which Dohrn ('81) described from the Gulf of Naples, constituting his genus Barana. This genus is undoubtedly very close to Parazetes, established by Slater ('79) for a pycnogonid from Japan, and possibly should be united with it. The chief difference appears to be the possession by Parazetes of only 9 joints in the palpi, but this is of the less importance when one considers that it is apparently the terminal joint which is lacking, and that the other joints have about the same relative proportions that they have in Barana. Slater lays emphasis on the point that in his specimen the proboscis was 4-cleft; but since the trimerous proboscis is almost universal[1] in all other known Pycnogonida, it is not unreasonable to suppose that he might have had a specimen possessing an individual abnormality. Unfortunately he gives no figures, which would greatly have facilitated the comparison of Parazetes with other

[1]In *Rhynchothorax mediterraneus* O. Costa the proboscis is said to consist of but two antimeres, owing to the failure of the dorsal antimere to develop (*cf.* Dohrn, '81, p. 211).

pycnogonids. Should later discoveries show these forms to belong properly in the same genus, the name Parazetes will take precedence over Barana.

As Sars ('91, p. 133) remarks, the genus Ascorhynchus is certainly very close to Barana, but Eurycyde appears to be well characterized. It seems to me doubtful that Nymphopsis [1] Haswell ('85) and Alcinous O. Costa ('61) belong in this family (Eurycydidæ).

Barana latipes sp. nov.

Pl. 1, Figs. 1–4; Pl. 2, Figs. 5–11

Type: Adult ♀, Museum of Comparative Zoölogy, no. 6947, Crustacea. Collected by Owen Bryant, from rocky shore, Sweeting's Village, Great Abaco, Bahamas, 22 July, 1904.

Trunk broad, compact, tapering somewhat posteriorly; segmentation well marked, the first three segments conspicuously enlarged dorsally and ventrally at their posterior ends, this enlargement forming almost a knob on the dorsal side. Lateral processes stout, about as broad as long, closely approximated but without touching, and each with a conical protuberance dorsally near its distal end. First trunk segment extending anteriorly from the eye tubercle in an elongate, cylindrical neck, which has distinct processes for the articulation of the palpi and the ovigera, the former at the anterior end, the latter immediately anterior to the processes of the first legs. The neck is prolonged at its anterior end into two sharp conical processes, beneath which the chelifori arise. Trunk and all its processes almost smooth and unarmed.

Caudal segment (Pl. 2, Fig. 7) elongate, horizontal, enlarged distally, and sparsely armed with a few scattered small spines; about as long as neck anterior to the processes for the ovigera.

Eye tubercle situated at the base of the neck and midway in the length of the first trunk segment; rather high and pointed forward; consisting of a smaller pointed dome placed on the anterior face of a larger conical elevation (see Pl. 1, Fig. 2). Eyes dark; in the smaller dome.

[1] More fully characterized by Schimkewitsch ('87, p. 128).

Proboscis large, trimerous, with three distinct lips at the tip (Pl. 2, Fig. 6); it arises from the ventral side of the neck at its anterior end, and is directed downwards and backwards, in which position it reaches back to the posterior border of the second trunk segment (see Pl. 1, Fig. 2). In outline it is seen to be fusiform, but is divided at about its distal third by a distinct groove; the basal part does not, however, constitute a distinct segment as in Eurycyde. The proximal portion expands rather regularly to its outer end, while the distal portion taken by itself is distinctly pear-shaped. In cross section, or as viewed from the end (Pl. 2, Fig. 6), the proboscis is triangular, the dorsal angle being directed downward as the organ is carried turned back under the body.

Chelifori (Pl. 1, Fig. 3) short, 2-jointed,[1] and armed with a few small, scattered spines. The basal joint, which expands somewhat distally, is only about as long as the breadth of one of the lateral processes, while the second joint is merely a minute rounded knob. No indication could be seen of a former chelate condition, though these organs undoubtedly possess chelæ in the larva.

Palpi (Pl. 2, Fig. 11) arising from small lateral processes at the anterior end of the neck; 10-jointed; joints 1 and 2 very short; joints 3 and 5 about equal in length, and much the longest of all; the former expands rather gradually distally, while the latter is broadest near its proximal end. Joint 4 equals in length about one third of joint 5; joint 6 is still shorter and bends at a right angle to 5; joint 7 is slightly longer than joint 6, and the succeeding joints, 8, 9, and 10, decrease gradually in size. These distal four joints normally lie in nearly a straight line and parallel with joint 5, and reach back about two thirds of its length. The first five joints are sparsely armed with small spines, which become more numerous, however, at the distal end of joint 5,

[1]Carpenter (: 05, p. 4) maintains with good reason that each of the parts of the chela, when present, should be counted as a joint. Without explanation, however, such a nomenclature is apt to introduce confusion, especially in those cases where the movable finger is reduced to the merest knob or projection on the palm, or may apparently disappear completely, as in the case of the species here described.

and are thickly set on the outer sides of all the succeeding joints, where they are about equal in length to the diameter of the joints. The whole palp, if extended straight backward, would reach about to the base of the caudal segment.

Ovigera (Pl. 2, Fig. 9) 11-jointed;[1] about a third longer (in the female) than the palp, the length to the principal flexure, between the fifth and sixth joints, being, however, almost exactly equal to the length of the palp to the corresponding place. Joint 1 short; joints 2 and 3 about equal in length, and longer than joint 1; joints 4 and 5 each slightly more than twice as long as joint 2 or 3; joint 6 bent backward upon joint 5, and only a little more than half as long; joints 7, 8, 9, and 10 grow successively smaller, both in length and in diameter; this part (the "terminal part") of the oviger is usually somewhat flexed. The terminal claw, which constitutes the eleventh joint of the appendage, is small and curved. The first four joints are practically free from hairs or spines; a few scattered short spines occur on joints 5 and 6; joints 7 to 10 are armed with three or four series of denticulate spines with deeply incised margins. These spines are longer on one side of the joint, and become smaller in each of the longitudinal rows as one moves across to the other side (Pl. 2, Figs. 9 and 10). Each of these joints has in addition near its distal end a rather strong simple spine. At the middle of the fourth joint is a prominent knob-like protuberance, which probably carries the opening of what Dohrn ('81, p. 123) calls the excretory organ.

Legs rather stout, somewhat less than twice as long as body from anterior end of neck to tip of caudal segment. Coxal joints (Pl. 2, Fig. 8) all short and broad, the second being a little longer than the first and third, which are about equal. The femur and first tibial joint are each a little shorter than the three coxal joints together, while the second tibial joint is slightly longer than the coxal region. Femur broadest, being about a third as long as broad; tibial joints narrower. These joints are flattened from side to side, so that the ventral margin forms rather a sharp edge.

[1] I agree with Dohrn ('81, p. 123) that the terminal claw should be counted as a joint.

First tarsal joint short, squarish, bilobed distally; second tarsal joint four to five times as long as broad, its inner (ventral) border only slightly curved, the outer (dorsal) somewhat more arched (Pl. 1, Fig. 4). Claw short and rather stout, less than a third the length of the second tarsal joint; somewhat curved towards the tip; auxiliary claws wanting. The coxal and femoral joints are only sparsely armed with short spines, which become longer and more numerous on the tibial and tarsal joints, especially long bristles (about as long as the breadth of the segments) occurring along the dorsal margins of the second tibial and second tarsal joints. On the ventral side of the second tibial joint near its distal end begin a number of thickly set short spines, which become more numerous on the tarsal joints and give to them a comb-like appearance. No "heel" is developed on the foot.

A few ova could be distinguished in the femoral joints, and the openings of the oviducts could be seen in the usual position on the ventral side of the second coxal joints of the second, third, and fourth legs, and they were probably present also on the first pair although they could not be made out.

Color in alcohol yellowish or light brown.

Measurements

Extent	14 or 15 mm.
Length, anterior end of neck to tip of caudal segment	3.8 mm.
Length of proboscis	2.2 mm.
Length of caudal segment	1.0 mm.
Length of cheliforus	0.33 mm.
Length of palp	2.8 mm.
Length of oviger	3.5 mm.

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PLATE 1

Barana latipes sp. nov., female

(All figures drawn with Abbé camera)

FIG. 1.— Dorsal view. × 12.
FIG. 2.— View from right side, the legs of that side removed. × 12.
FIG. 3.— Left cheliforus. × 50.
FIG. 4.— Foot of second leg of right side. × 50.

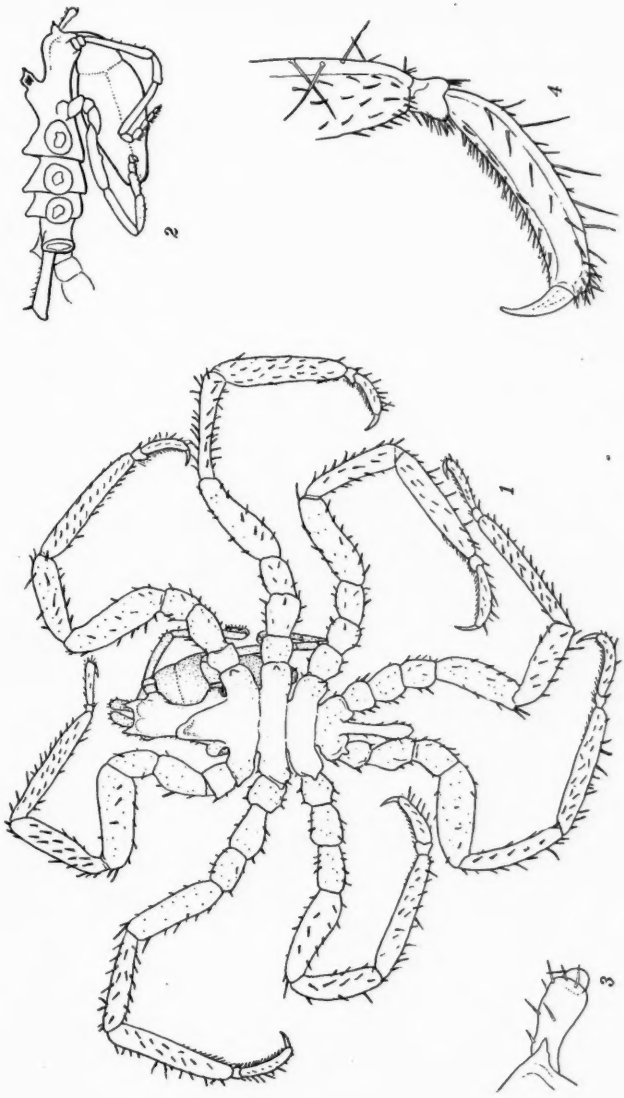

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PLATE 2

Banara latipes sp. nov., female

(All figures except Fig. 6 drawn with Abbe camera)

FIG. 5.— Trunk and proboscis, with right cheliforus, palp, and oviger, as seen from below. These appendages have been removed from the left side. × 16.
FIG. 6.— Proboscis viewed directly from the end.
FIG. 7.— Caudal segment from above (dorsal view). × 50.
FIG. 8 — Coxal joints of second right leg; *o*, position of external genital opening. × 20.
FIG. 9.— Oviger of left side; *v*, row of spines shown enlarged in Fig. 10. × 50.
FIG. 10.— Row of denticulate spines marked *x* in Fig. 9. × 213.
FIG. 11.— Palp of left side. × 50.

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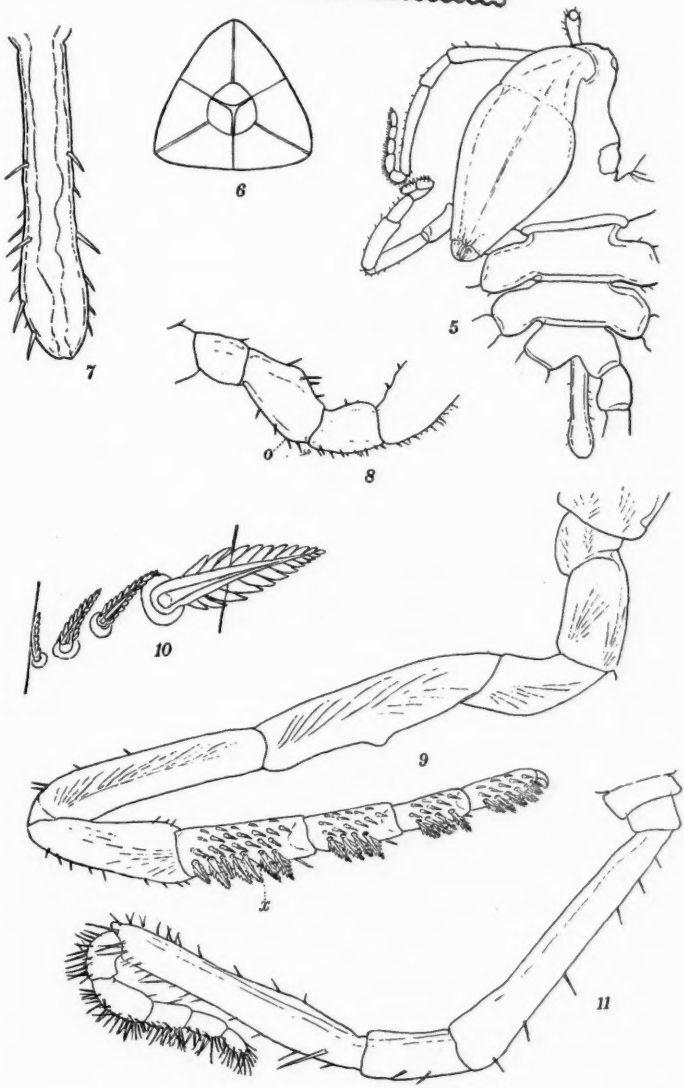

ADDITIONAL NOTES ON BAHAMA SNAKES

THOMAS BARBOUR

THE specimens which form the basis of this paper are now all the property of the Museum of Comparative Zoölogy at Cambridge, Mass.

In December, 1904, a paper[1] was published in which a good series of lizards but rather few snakes were reported on. Now an opportunity is presented to offer notes on about forty specimens of Ophidians, for last winter Mr. A. E. Wight collected a number of fishes and reptiles during February and March; while later Gustav Sabille returned to New York from Nassau with an interesting lot of living snakes. These were also purchased and advantage has been taken of this opportunity to study the species while yet alive. Five examples of the New Providence Island Boa from five to perhaps eight feet long have been presented to the New York Zoölogical Society. They are still alive in the Reptile House at Bronx Park, where shortly after their arrival two specimens simultaneously gave birth to thirty-eight young. I regret that I do not know the number in each litter. Mr. R. L. Ditmars has also told me that several specimens of *Alsophis vudii* ate a few Ungualiæ which were in the same case and have refused other food.

Since the afore-mentioned paper was published, Dr. Leonhard Stejneger has published an excellent analysis of the herpetology in a volume[2] on the Bahamas edited by Dr. Shattuck of Baltimore. In general I agree very heartily with Dr. Stejneger's conclusions, but doubt whether *Typhlops lumbricalis* will ever be found on New Providence. I, as well as others, have searched carefully for it on this island and have never heard of its occurrence. With

[1]Barbour, Thomas. "Batrachia and Reptilia from the Bahamas." *Bull. Mus. Comp. Zoöl.*, vol. 46, no. 3, pp. 55–61.

[2]*The Bahama Islands.* Edited by George Burbank Shattuck. The Geographical Society of Baltimore; New York, The Macmillan Co., 1905, xxxii + 630 pp., plates and text figs.

far less opportunity to hunt for it carefully I obtained a specimen near Marsh Harbor, Abaco, on July 6, 1904. I imagine that for some unknown reason this species has skipped New Providence in its northward progression, as *Liocephalus carinatus* appears to have done, though, to be sure, the species has not yet been taken on any island except on Great Abaco.

For the Northern Bahaman Boa Boulenger's and Stejneger's application of Fischer's name is undoubtedly correct.

Epicrates striatus Fischer.

E. strigilatus Cope. Barbour, *Bull. Mus. Comp. Zoöl.*, vol. 46, p. 59.

Six specimens just born, and one considerably older; all New Providence Island stock. The very young ones are about $14\frac{1}{4}$ inches long; the tail takes up $2\frac{3}{4}$ inches of this length. The color of these young is considerably lighter than that of adults, the opalescence is if anything more marked. One specimen is diffusely blotched with white laterally.

An older specimen measures $28\frac{1}{2}$ inches in total length but part of the tail is gone. This example is much darker in color than the small ones. The pattern is the broken irregular one which is characteristic of the adults of the species. In the very young ones, on the other hand, there is a dorsal series of light blotches separated by darker; below this laterally there is a light chestnut stripe very iridescent; below this again are three darker stripes, the uppermost lightest, the middle one darkest. Between these are two light bands, the upper one buffish, the lower one almost white. The bellies are ivory white.

The natives call this the "fowl snake." The squamation of this species is typically so variable that the counts of these specimens are of no especial interest.

Ungualia pardalis Gundlach.

Six specimens, all from New Providence Island. One of these is younger than any examined heretofore.

In my previous paper the dichromatism of this species was mentioned. This is also shown very well among these specimens. One about 12½ inches long is almost uniform buffish brown above with a lateral row of small darker markings. A few dark markings are on the gastrosteges, which are yellow. The tail is blackish above for one inch, below for less than ¼ inch. Two other specimens of about the same size are slaty blue with two dorsal rows of squarish darker blotches. Between these pairs of markings is a narrow very light band. Two others are brown with a double row of dorsal markings. The sixth, and smallest, is 5¼ inches long. It is slate-colored, the dorsal markings are fused. There is a very distinct lateral row of squarish spots and on the gastrosteges posteriorly there are two rows of dark spots generally in pairs. The distal ½ inch of the tail is bright yellow with the extreme tip black. Previously it has been noted that the amount of black on the tail seemed correlated with age. The scale counts of these specimens are given in the same order as that in which they have been mentioned:—

Sc. $\frac{13}{152+31}$; $\frac{25}{149+31}$; $\frac{23}{152+30}$; $\frac{23}{157+33}$; $\frac{23}{153+31}$; $\frac{23}{153+33}$

The natives call these "thunder snakes," because they say that they frequently crawl about after severe rain storms.

This species is most frequently taken among the heaps of broken rock which are piled about the trunks of orange trees; or under stone walls. I have never seen one above ground.

Alsophis vudii Cope.

Twenty-four specimens, all from New Providence Island.

The largest specimen is 43 inches in total length with the tail 12 inches long. The smallest is about 21 inches long, with the tail nearly one third of the total length.

The color of this species is vastly more variable than published descriptions and material previously examined, had suggested. One large one about 40 inches long, has the head and neck mottled black and rich reddish brown. There is a black stripe on each side of the neck. The color gradually changes until the posterior

half of the creature is deep lustrous brown-black. Another specimen is brick red above and almost salmon-color below. Still another is uniform ashy gray above, marbled with darker below. The top of the head is richly puncticulate with black and red-brown. There is a dark stripe through the eye, also several dark blotches on the neck region above. A number of specimens are rich chocolate brown both above and below, often with a light-edged dark stripe running through the eye. Several examples are brown above and pinkish beneath. The last specimen which I shall mention is dark iron-gray anteriorly, shading posteriorly into olive-brown. This one also has a light-edged dark stripe through the eye.

The Cuban specimens of *A. angulifer* do not show such variation. I can but think that the Bahaman examples are worthy of specific distinctness.

The natives call this "chicken" or "whip snake." I have added the scale counts of these individuals thinking that perhaps they may be of use for comparison when someone procures a large series of the Cuban form. It is remarkable how many of the tails are imperfect.

New Providence Island specimens:—

$$\frac{17}{170+108};\ \frac{17}{165+\ ?};\ \frac{17}{109+\ ?};\ \frac{17}{165+104};\ \frac{17}{167+105};\ \frac{17}{164+\ ?}$$

$$\frac{17}{169+?};\ \frac{17}{166+107};\ \frac{17}{159+112};\ \frac{17}{169+111};\ \frac{17}{162+\ ?};\ \frac{17}{171+19}$$

$$\frac{17}{163+116};\ \frac{17}{163+101};\ \frac{17}{165+109};\ \frac{17}{168+110};\ \frac{17}{170+107};\ \frac{17}{165+117}$$

$$\frac{17}{165+106};\ \frac{17}{166+?};\ \frac{17}{164+119};\ \frac{17}{170+111};\ \frac{17}{169+113};\ \frac{17}{162+119}$$

Other specimens in the Museum collection show the following scale counts:— $\frac{17}{167+?};\ \frac{17}{170+101};\ \frac{17}{164+118};\ \frac{17}{161+\ ?}$

The four following are from Andros. Island:—

$$\frac{17}{171+121};\ \frac{17}{166+?};\ \frac{17}{161+?};\ \frac{17}{164+118}.$$

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